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A Summary of Current Program 7/1/65

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and Preliminary Report of Progress

for 7/1/64 to 6/30/65

ANIMAL HUSBANDRY RESEARCH DIVISION

of the

AGRICULTURAL RESEARCH SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE

and related work of the

STATE AGRICULTURAL EXPERIMENT STATIONS

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CURRENT SERIAL RECORDS

This progress report is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on USDA and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of USDA and cooperative research issued between July 1, 1964, and June 30, 1965. Current agricultural research findings are also published in the monthly USDA publication, Agricultural Research. This progress report was compiled in the Animal Husbandry Research Division, Agricultural Research Service, U. S. Department of Agriculture, Agricultural Research Center, Beltsville, Maryland.

UNITED STATES DEPARTMENT OF AGRICULTURE

Washington, D. C.

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INTRODUCTION

Research in livestock production will benefit the public through lower-cost animal foods and an assured supply of high quality foods more suited to their needs. It assists individual farmers by lowering costs and increasing net income. It will also improve the utilization of the surplus grain supply. More efficient high producing animals of the various classes will aid the small farmer particularly, permitting a more diversified enterprise. They will strengthen rural area development programs by making livestock farming on a small-scale more attractive.

The mission of the Animal Husbandry Research Division is to conduct research which will reduce costs of animal production, provide the consumer with animal products of improved quality, and provide basic animal science information. As more of the simpler practical problems of animal production are solved, more complex problems must be attacked. For solving these complex problems basic information on the genetics, physiology, and nutrition of livestock is necessary. Even though such basic information is obtained in the Animal Husbandry Research Division by the majority of our scientists, increasing emphasis is placed upon basic research and studying problems in depth.

The investigations of the Animal Husbandry Research Division are carried out by a staff of approximately 500 persons, of whom about 160 are professional research scientists. The work is conducted at Beltsville and at field locations throughout the United States. Many of the projects are carried out cooperatively with State agricultural experiment stations, and some with other Federal agencies, other divisions in the Agricultural Research Service, and non-federal organizations. Investigations are carried on in various aspects of genetics and breeding, nutrition and feeding, feed composition and evaluation, anatomy, physiology, and management. National cooperative record of performance programs are conducted with dairy cattle and poultry. Research also is conducted on the quality of meat, milk, and eggs, as influenced by production factors; on the control of avian leukosis in poultry; and on the basic metabolism in the animal body of pesticides, hormones, and other chemicals used in agricultural production and the effects of these chemicals on animal products.

It is frequently costly and unwise to make extensive program shifts until a promising and worthwhile research project is completed. Furthermore, most animal husbandry investigations are necessarily long term in nature. Consequently, it is easy to lose sight of the degree to which progress has been made in a yearly published report such as this. A few of the more recent developments which have made marked contributions to the industry and/or to their research activities are mentioned briefly below.

All-grain rations can be used in cattle feeding. Steer feeding trials with all-concentrate finishing rations, based on corn, barley, milo, or wheat, demonstrated that: (1) cattle do not require roughage for health and efficient growth, (2) the addition of certain minerals found in roughages are of no benefit when added to the all-concentrate rations, (3) vegetable proteins are not superior to urea as a source of supplementary nitrogen, (4) wheat can be fed as the major source of carbohydrates, and (5) carcass quality is equal to that produced when roughage is fed. Studies also have shown that calves can be wintered satisfactorily by substituting barley for part or all of the hay.

Control of estrus in swine. A synthetic drug mixed with feed resulted in groups of gilts coming in estrus and being bred over a three-day period. No adverse effects were observed and normal litters were farrowed at the end of normal gestation periods. This research offers for the first time the possibility for (1) extensive use of artificial insemination in swine, (2) more efficient use of facilities and labor by scheduling the date for groups of sows, (3) breaking disease cycles in baby pigs by avoiding overlap in farrowings, (4) producing market hogs in uniform groups, and (5) more effective research by controlling the birth date of experimental animals.

Oral iron effective in preventing cotton pelt in mink. So-called "cotton pelt," a condition in mink which renders the fur almost valueless, is apparently caused by an anemic condition in the animal. It often occurs when mink are fed high fish diets. The cause and possible avoidance of this condition has been under study at Petersburg, Alaska. Supplemental iron was found effective as a corrective measure when it was injected. In further research it was found that when ferrous fumarate, a highly soluble iron compound, was added to the diet "cotton pelt" was effectively avoided. The addition of this compound to the high fish diet also resulted in better general health and production.

Parthenogenesis increased in presence of live virus. A possible relationship between certain live viruses and parthenogenesis in turkeys and chickens has been observed at Beltsville. Fowl pox, Rous sarcoma, and Newcastle disease viruses, each has been shown to be effective in enhancing parthenogenetic development in turkeys. When the viruses were inactivated with beta propolactone prior to inoculation into turkeys, they proved ineffective in enhancing parthenogenesis. Spontaneous parthenogenesis in unfertilized White Leghorn eggs also has been noted following a natural outbreak of visceral lymphomatosis. The observation that live viruses will stimulate cell division and growth will be useful to the research worker but also may have far-reaching implications in animal and human health.

Uniform blood typing results. A comparison testing program was established in 1956 by the USDA among cooperating blood typing laboratories. The original purpose was to improve repeatability of blood typing results from one laboratory to another. Twenty-two laboratories from 17 different countries participate. As a result of this coordinating effort, research results all over the world are repeatable and can be uniformly interpreted.

An analysis of more than 75,000 individual tests of cattle red blood cells established that laboratory tests of duplicate cells produce the same results 99% of the time. New blood typing reagents developed in different parts of the world are quickly recognized. Agreement on identification nomenclature for several new blood factors has been obtained. Newly developing laboratories find the program particularly useful because they see how they "measure up" with the established laboratories.

Cow raised on PROTEIN-FREE ration gives birth to normal calf. An Angus heifer was raised on a protein-free, chemically pure ration. During the 26-month experiment, body weight increased from 290 to 930 lbs. The heifer matured sexually, conceived, and delivered a 51 lb. heifer calf while consuming this ration. This accomplishment provides a new research tool for the study of the nutritive requirements for cattle reproduction.

Early weaning of lambs reduces parasitism. Weaning lambs at 60 to 70 days so that they are not grazed with their mothers has resulted in a much lower incidence of internal parasitism and more rapid growth. This procedure provides a practical and economical means of controlling internal parasites in lambs. However, lambs weaned at less than 30 days, or under 25 pounds in weight may require special feed and care.

Method for making genetic progress for milk yield. A method for evaluating DHIA cows and identifying those of outstanding breeding value for extensive use was initiated recently. The procedure considers the cow's deviation from herd mates, her paternal half-sister's deviation from herd mates, and adjusts for the number of milk and milk-fat records of the cow and daughters of her sire. Of the more than 1/2 million cows evaluated annually by AHRD, the top 2% are identified and the results made available to the dairy industry, along with genetic appraisals of sires in DHIA. These estimates of breeding value, when fully and effectively implemented through artificial insemination, can more than double the current rate of genetic progress for milk yield in the Nation's dairy herds.

Breeding for resistance to leukosis. Relatively simple breeding procedures for developing strains of chickens resistant to the growth of leukosis viruses are suggested by research findings at the Regional Poultry Research Laboratory at East Lansing, Michigan, and at other laboratories. Two different single genes have been identified, each having a somewhat different effect on the antigenic response. Homozygous recessive chickens, or cell cultures from such chickens, have a greatly reduced ability to support growth of certain specific viruses. While these results are promising, further tests on the effects of these genes on neoplasms occurring under widely different conditions of exposure are necessary before specific recommendations can be made to poultry breeders.

AREA NO. 1: ANIMAL BIOLOGY

Problem. The extent of applicable results in animal husbandry research is severely limited by a paucity of basic information on the genetics, nutrition, and physiology of our livestock. The basic research in progress has resulted primarily in revealing the inadequacy of our information regarding the functional processes within the animals we are trying to control and develop for human use. Basic research is required in such fields as animal cell metabolism and reproduction, enzymology, physiological bases for heredity, and microbiology of the rumen and intestines. Results of such studies provide the basis for additional research applied to the husbandry of each type of livestock.

USDA AND COOPERATIVE PROGRAM

This area consists of basic research conducted by geneticists, biochemists, physiologists, and nutritionists. It includes studies in the Pioneering Laboratories on somatic variations of red cell antigens, on the nature of the specificity of antigens and antibodies, on methods and theories of population genetics, and on the physiological aspects of hormones. Research in reproductive physiology is in progress to determine the biochemical composition and the defensive mechanisms of the uterus. Still other physiological investigations are involved with the response of mammary tissue to invasion by infectious agents. One study of long standing has the primary objective of describing, fully and in detail, the gross and microscopic anatomy of the domesticated fowl. Research on the metabolic role of vitamin B₁₂, the investigation of unidentified nutrients in food and feed, and biological and chemical studies of rumen metabolism are also being undertaken. Investigations are in progress on the development of counter measures to prevent contamination of animal products by fallout from nuclear explosions. The work is conducted at Beltsville, Maryland; East Lansing, Michigan; and in cooperation with the Indiana, Iowa, Maryland, Michigan, Minnesota, New York, Utah, and Wisconsin Agricultural Experiment Stations.

The Federal scientific effort devoted to research in this area totals 26.5 professional man-years. Of this total, 6.0 are in agricultural chemicals, 5.0 in avian anatomy, 4.0 in genetics, 5.9 in physiology, 2.0 in nutrition, 2.6 in rumen function, and 1.0 in radioactive fallout.

There are 8 grants involving Public Law 480 funds in foreign countries financing research related to animal biology. Two are with the National and University Institute of Agriculture, Rehovot, Israel, and provide for (1) studies on the separation of young and old spermatozoa and (2) investigation of factors affecting long-term storage of sperm. They are supported for 3 years (1963-1966) with a total of \$86,904 equivalent in Israeli pounds.

There are 3 PL 480 projects in Poland. One is on the secretion of anterior pituitary hormones and ovulation in small ruminants. It is supported for 5 years (1960-1965) by \$52,455 equivalent in Polish zlotys at the Polish Academy of Sciences, Jablonna. A 4-year project (1962-1966) at the College of Agriculture, Poznan, is concerned with protein compounds of vitamin B₁₂ and its analogs. It is supported with \$38,138 equivalent in Polish zlotys. Another project is at the Polish Academy of Sciences, Warsaw. It involves the determination of the metabolic pathway of protein biosynthesis in the liver and has a 5-year duration with support amounting to \$60,411 equivalent in Polish zlotys.

A project entitled, "Study of metabolism of zinc in living organisms by means of zinc 65," is in progress at the Institut Espanol de Fisiologia y Bioguimica, Madrid, Spain. It has a duration of 4 years (1961-1965) and is supported by \$35,277 equivalent in Spanish pesetas.

The University of Montevideo, Uruguay, is conducting a project of 5 years' duration on the nutritional value of fish silage. It has \$112,785 equivalent in Uruguayan pesos of support.

A project was initiated with the Hebrew University, Jerusalem, Israel, on the effect of X-rays on viability genes with special reference to their action in heterozygotes and to the mechanism of heterosis. The project duration is 4 years and has support of \$34,650 equivalent in Israeli pounds.

PROGRAM OF STATE EXPERIMENT STATIONS

Physiological conditions associated with the female animal in the onset of puberty, estrus, pregnancy, and lactation are being studied with primary emphasis on the levels and interaction of the several hormones. Endocrine and environmental influences on egg production of birds are being investigated. Many of these studies require detailed chemical and histological determinations. Detailed efforts are also required with semen including production, evaluation, and preservation. One such study includes comparison of mature and immature spermatozoa and somatic cells with respect to nucleic acids and lipoprotein-carbohydrate complexes. A portion of this work is conducted under regional projects NC-41, Endocrine Factors Affecting Reproduction in the Bovine Female; W-49, Physiological Factors Affecting Fertility in Cattle; NCR-45, Poultry Physiology; and NCR-26, Artificial Insemination of Swine. Eleven States in the western region and the U. S. Department of Agriculture are cooperating in regional project W-46, The Effects of Environmental Stresses on Range Cattle and Sheep Production.

Laboratory animals such as mice, rats, quail, fruit flies, and flour beetles are used to develop and evaluate new animal breeding concepts for later application to domestic animals. Automatic data processing machines also provide early testing and evaluation of genetic theory. Research on gene

action makes use of genetic defects such as dwarfism in beef cattle and riboflavin deficiency in chickens. Blood group genes, histocompatibility loci, and plumage color genes are studied in relationship to economic traits. Biochemical mechanisms and cytogenetics of domestic animals are now receiving more attention. Much of this research is coordinated under NCR-21, Population Genetics.

Basic studies on nutrient metabolic pathways and related enzyme systems of poultry, swine, sheep, and dairy and beef cattle are in progress. Other aspects under investigation are nutrient interrelationships and toxic factors in feedstuffs as they affect requirements for growth, egg production, gestation, and lactation. Natural dietary chelates and their effect on trace mineral metabolism, plane of nutrition and resistance to disease, dietary effects upon maturation of digestive function in both ruminant and non-ruminant animals are being investigated. The use of laboratory animals in pilot studies for large animal nutrition, or to determine basic nutritional principles, is also included in this area. There are several cooperative regional projects (NC-63, NE-24, NCR-42, S-45, and W-34) that are considering various factors affecting the nutritive requirements of livestock and the nutritive value of feedstuff.

The State stations have 214.0 professional man-years devoted to Animal Biology.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Agricultural Chemicals

This research on basic metabolism, fate and role of agricultural chemicals ingested by livestock is conducted at the Metabolism and Radiation Research Laboratory, Fargo, North Dakota.

1. Herbicides. The metabolic fate of the triazine herbicides in the animal has received little attention, although these compounds are extensively used for weed control. Research has been initiated with propazine (2-chloro-4, 6-bis-(isopropylamino)-1,3,5-triazine) and simazine (2-chloro-4, 6-bis-)ethylamino)-1,3,5-triazine). Results indicate that the rat readily metabolizes and excretes propazine and simazine. Within two days of the administration of C^{14} ring-labeled propazine dissolved in corn oil, 85% of the ring had been excreted in the urine and feces. None of the ring activity appeared in the respiratory CO_2 , indicating that no ring cleavage had taken place. The repeatability of this rate of excretion from animal to animal was very good, with 66% of the C^{14} appearing in the urine within two days. Conditioning the animal to the presence of propazine in the diet had little effect on this metabolism. Simazine, labeled with C^{14} in the ethylamino side chains, was similarly administered to the rat. The side chains were rapidly metabolized by the rat. Radioactive respiratory CO_2 appeared within 30 minutes of administration. Seventy-eight percent of the activity excreted in the CO_2 , urine, and feces appeared within 48 hours.

The above data indicate that the triazine ring remains intact and that the side chains are removed, possibly by oxidative deamination. It is not known, however, if the isopropylamino groups of propazine will be handled in the same manner as the ethylamino groups of simazine. If the metabolic pathway of propazine should be oxidative deamination of hydroxy-propazine, one should find cyanuric acid in the urine. No activity could be found by gas chromatography in the area where methylated cyanuric acid appears.

In another study, ring-labeled C¹⁴ propazine was administered by capsule to a milk goat. Urine was sampled hourly, milk every 4 hours, and feces every 24 hours; tissues were sampled at the termination of the experiment. To date only the urine has been assayed for radioactivity. Radioactivity was detected in the urine one hour after dosing, with 42% of the activity being excreted in 72 hours. (AH k1)

2. Feed additives. Prior research has shown that the iodine of diiodosalicylic acid (DIS) used as a carrier of iodine in some mineralized salts is only partially available to the animal. Studies of the metabolism of this compound in the animal are in progress to determine if DIS interferes with the binding of thyroxine by specific plasma proteins, and to identify the metabolic products of DIS metabolism. DIS was added to fresh plasma in a range of concentrations. The plasma was subjected, in the presence of I¹²⁵ labeled thyroxine, to electrophoresis on cellulose acetate strips with a barbitol buffer at pH 8.6. In all cases, the radioactivity was concentrated in a band close to the alpha globulin region, and there was no effect on the binding of thyroxine by presence of DIS. DIS labeled with I¹²⁵ was synthesized, and added to bovine serum in vitro. After electrophoresis, the radioactivity of I¹²⁵ was again found in a band corresponding to the location of the albumen fraction.

A lactating dairy cow was given approximately .75 mc. of I¹²⁵ labeled DIS orally in a gelatin capsule, and urine, feces, and milk were analyzed for radioactivity. Estimates of radioactivity in the thyroid were made. At the end of 7 days postdosing, 75.2% of the dose had been excreted in the urine, feces, and milk. In addition, the thyroid contained approximately 4.1%. This accounted for 80% of the administered dose. Some loss of urine did occur, which could account for an additional but unknown amount. The results suggest that the majority of DIS excreted in the urine is still in the original form ingested. Efforts are being continued to further purify the extracts in order to achieve more definite identification of the urinary excretion products. (AH k1)

3. Microbiological studies. Microbiological studies have been initiated to investigate the role of the rumen microorganisms in the metabolic fate of agricultural chemicals in the ruminant animal, and the physiological and metabolic effects these chemicals have on the rumen flora. Considerable effort has been devoted to developing and establishing techniques and methodology for the in vitro screening of the extent of ruminal bacteria

metabolism of agricultural chemicals. Some 42 pesticides, insecticides, and herbicides were incubated with rumen bacterial suspensions for 50 to 80 minutes without showing significant endogenous gaseous increases. Thus the chemicals did not affect the metabolism of the microbes. Furthermore, Trifluralin, Amitrole, and Tabutrex were not utilized as a carbon source for growth in synthetic or complex mediums devoid of carbohydrates.

A 10-day continuous culture experiment was conducted in an effort to adapt a mixed rumen bacterial population to Amitrole in a 0.1% (w/v) concentration. The culture medium during this experiment was collected, freeze dried, extracted, and eluted on cation exchange resin columns. Thin layer chromatography of the eluted materials indicated that no metabolites were formed. Also, three consecutive 24-hr. serial inoculations were made into fresh medium containing Amitrole. The final inoculation was dispensed in C^{14} -Amitrole and allowed to incubate for 72 hours. No C^{14} metabolites were indicated.

Short-term experiments with millipore filtration techniques indicated that a mixed rumen-bacterial cell suspension of E. simplex will not take up C^{14} Amitrole. Steam distillation experiments indicated no C^{14} volatile materials present in rumen-bacterial inoculated media.

Ring-labeled C^{14} propazine and C^{14} atrazine and side-chain-labeled C^{14} simazine showed no metabolites with mixed rumen-bacterial populations when incubated in media varying in levels of organic nitrogen or carbohydrate constituents for periods of 1 week duration. Gaseous materials from these cultures were compared to the gases from a uniformly labeled C^{14} glucose culture, run in parallel with the pesticide substrates. No alterations of the pesticidal substrates were indicated with paper chromatography. (AH k1)

B. Avian Anatomy

Continued progress has been made on the study of the integumentary system. Text and illustrations for the first chapter on the origin of birds and breeds of fowl have become so voluminous that it will be completed as a separate book. Of the remaining 11 chapters, for which chapter titles were given last year, 7 have been completed or nearly so. Approximately 400 illustrations have been completed, about 100 of which were done this year. The integument is being described for 5 domesticated species, chicken, turkey, domestic duck, Coturnix quail, and common pigeon.

In order to present at least a sample of factual data from these studies, mention will be made of the anatomy and histology of the sternal bursa. In spite of the importance of breast blisters, no publication exists on the normal structure of this organ and all terms used here are new. An incision through the skin of a normal adult chicken, in the mid-ventral line of the keel exposes a flattened superficial bursal cavity. Intrabursal connective tissue strands extend across the mid-line and attach to the dorsal surface

of the dermis. The peripheral boundary of the cavity is not clearly defined, and air foam vesicles along the perimeter may be present. The bursa may be made up of 2 instead of a single cavity. The second, or deep bursal cavity, lies parallel and dorsal to the superficial cavity. The layer separating them is a dense sheet of connective tissue, the intrabursal lamina. It may be perforated by intrabursal stoma which connect the 2 cavities. The deep cavity is not crossed by intrabursal connective tissue strands. The roof of the deep bursal cavity is a glistening sheet of dense connective tissue that forms the periosteum of the overlying keel bone.

Microscopic sections show a thick cornified epithelium and a dense dermis. The connective tissues that form the strands are often in the form of whorls. The connective tissues of the intrabursal lamina are densely packed. The connective tissue cells are flattened so that cavity surfaces are smooth.

The delicate intrabursal connective strands may become enlarged and form massive bars crossing the superficiae. The stoma may be coalesced so that the superficial and deep cavities are widely confluent. This range of morphologic variation occurs in the turkey as well as in the chicken. A sternal bursa is absent from young domesticated birds and it remains still a question whether a sternal bursa is a normal structure or develops only as a result of friction and irritation as certain atypical ones in man. For example, individuals who carry heavy loads on their shoulders may develop bursa where they are not normally present. (AH e8-1)

C. Genetics

1. Methods and theories of population genetics. The nature and causes of selection plateaus, and methods for overcoming them, are being explored in mice. The two populations being used are Goodale's Large White Strain (G) and Falconer's NF Strain (F). Strain G has been selected for large 60-day body weight for more than 90 generations. Strain F had been selected by Dr. D. S. Falconer of Scotland for large 42-day body weight for 34 generations prior to importation. It has been selected for an additional 22 generations for large 60-day body weight since then. Analyses show that the G Strain has been plateaued for more than 50 generations. During this period, realized heritability was approximately zero, but estimates of heritability by the usual methods remained positive and appreciable. Strain F also appears to have reached a selection plateau for 60-day body weight.

Reciprocal crosses were made between Strain G and Strain F. In addition, the pure strains, F and G, were reproduced from the same selected males. Females were unselected and were assigned at random to pure or straincross matings. Strains G and F were very similar in body weight at weaning (28 days) and at 42 and 60 days of age. This was the case for both sexes, with a slight advantage in favor of Strain F. It is rather surprising to find that two strains with such different origins and selection histories

have plateaued at approximately the same level of body weight. Although average litter size at birth differed, average litter size at weaning was almost the same (6.6 offspring) in the two strains. Estimates of the heritability for body weight at 28, 42, and 60 days of age (based on the regression of male offspring on sire) were .11, .10, and .54, respectively, in Strain G; and 0, 0, and .11, respectively, in Strain F. Estimates of heritability at the same three ages, based on regression of female offspring on sire, were 0, .10, and .69, respectively, in Strain G; and 0, 0, and 0 in Strain F. The bias in heritability estimates of 60-day body weight persists in Strain G but is probably absent in Strain F. It appears that the plateau in Strain F has occurred because of the depletion or near-depletion of additive genetic variation.

The average amounts of heterosis obtained in the reciprocal straincross were 0%, 2%, and 3.2% for body weight at 28, 42, and 60 days of age, respectively. These amounts are less than expected. Litter size at birth was only 2% larger for straincrosses than for pure strains, but the difference increased to 8% for litter size at weaning. There was lower mortality in straincross than pure strain offspring. Estimates of heritability of litter size were .18 in Strain G at birth and zero at weaning, but were zero at both times in Strain F. Strain G is known to have a high secondary sex ratio (% males at weaning) and this was also observed in the straincross litters produced by Strain G females. No evidence of heritability of sex ratio was obtained.

The differences between body weights of reciprocal straincrosses were significant for each sex at each age. Offspring from the F male x G female mating were larger than those from the reciprocal cross. These differences may be due to differences in maternal effects and sex-linkage, but the excellent nursing ability of Strain G dams is probably a major factor.

Selection has been continued in the Goodale population selected for percentage of white hair, and a relaxed selection group has been established. The total number of all-white individuals has been increased to 29, and only six of these were females. The difficulty in reproducing this strain and obtaining satisfactory selection differentials has been alleviated by testing and then using a high-fat ration during mating and nursing. Large increases were obtained in litter size at weaning, weaning weight, and post-weaning survival. This should improve selection progress. No effect of the ration change on the selected trait was noted.

The cross of all-white males with females from an unselected strain has been carried through the F₃ and F₄ generations. The skewed distributions and low mean percentage of white persist. Inbred lines with various percentages of white hair are being started from F₄ individuals.

The genetics of some biochemical traits related to growth are being studied. Intra-peritoneal injection of mice with C¹⁴-labeled alpha-aminoisobutyric

acid at 27, 41, or 59 days of age was followed by slaughter 28 hours later. The chemical is a non-metabolizable amino acid. Two inbred strains with different growth rates and a cross between them were studied. Radioactivity was measured in blood plasma, liver, and muscle tissue in a liquid scintillation counter. The ratio of tissue to plasma activity provides a measure of the rate of protein metabolism. Preliminary results indicate that metabolic activities of both liver and muscle tissue exhibit individual and strain differences.

An experiment is under way which seeks to establish detailed curves (and mathematical expressions) for growth in four selected and unselected strains of mice. Body weight and tail length are measured on individuals at 3-day intervals from 3 to 60 days of age and at 6-day intervals from 60 to 96 days. Results of the first replication indicate distinct changes in growth rate in some strains and very smooth curves for tail length measurements. (AH p-2)

2. Basic research on blood antigens and antibodies.

(a) Somatic variation of red cell antigens. In studies of somatic variation of pigeons the anti-A agglutinin, Phaseolus lunatus, has been used. The antigen on pigeon red cells has been identified as serologically similar to, if not identical with, the A₂ substance of human red cells. However, the pigeon A₂ substance is not inherited in the apparently simple fashion of the human A₂ substance. Preliminary family data indicate that the amount of the A₂ antigen in pigeons is inherited and that there is more than one gene involved in the production of the pigeon A₂ substance.

A comparison has been made of the red cell agglutinin titer and the A-inagglutinable cell frequency in pigeons, as determined by an isotope dilution procedure using chromium⁵¹. A very close relationship was found between cell titer and the inagglutinable cell frequency, which suggests a high correlation between the inagglutinable cell frequency and the genotype for the A₂ antigen.

Studies of the radiation effect on the frequency of the A₂ inagglutinable cells were continued employing a dose rate of 360 r of x-rays. The results obtained were as follows:

<u>Sex</u>	<u>Treatment</u>	<u>Change in inagglutinable cell frequency after irradiation</u>	
		<u>Time After Irradiation</u>	
		<u>2 Months</u>	<u>4 Months</u>
Males	1. Irradiated	1.88 ± 0.69	3.72 ± 0.76
	2. Non-irradiated	0.27 ± 0.45	-0.70 ± 0.31
Females	1. Irradiated	3.41 ± 1.01	5.97 ± 1.77
	2. Non-irradiated	1.42 ± 0.06	-0.05 ± 0.71

The responses of both irradiated males and females, on the average, were significantly greater than their respective non-irradiated controls both at 2 months and at 4 months. They were also significantly higher than the pre-irradiation frequency. Most birds who responded poorly at 2 months showed a definite response at 4 months post-irradiation.

The apparent failure of some pigeons to respond following x-irradiation has been considered previously. Additional irradiation of these birds resulted in a decrease in the number of inagglutinable cells and negative selection was suggested as an explanation for this result. Survival of the A₂ inagglutinable cells was tested by injecting Cr⁵¹ labeled blood back into the donor from which it was drawn and by comparing the inagglutinable cell frequency prior to labeling with that of the labeled blood drawn 7 days following transfusion. Three birds tested in this way showed a marked decrease (-5.32, -2.45, and -5.39) in the number of inagglutinable cells. In contrast the total cell population survival was normal. These results indicate that the A₂-inagglutinable cells are undergoing negative selection. Results of a similar experiment conducted with birds previously exposed to x-irradiation are also indicative of selection against the A₂ negative cells. (AH p-1)

(b) Antibody specificity. Previous investigations have established the presence of agglutinins in human sera specific for human A₂ red blood cell stroma which can be differentially eluted at various temperatures. It was believed that the thermally dissociated fractions varied in size. To test this hypothesis, two types of experiment were conducted. In the first, gradient ultracentrifugation with linear gradients of sucrose between 20-39% were employed. Density gradient fractions were absorbed to ghosts and elutions carried out at 37°, 45°, and 56° C. In the heaviest fraction, 40.7% of the agglutinin was eluted at 56° whereas only 25.7% was eluted at 37°. The proportion of material eluted at 56° decreased progressively from the heavier to the lighter weight components. In contrast, the amount of serological activity eluted at 37° increased from the heaviest fraction to the lightest fraction. The ratio of activity eluted at 37° to that eluted at 56° was 0.634 and 3.21 for the heaviest and the lightest fraction, respectively.

In the second type of experiment, eluates obtained by thermal dissociation were subjected to starch gel electrophoresis. The ratio of eluates migrating to the cathode versus the anode was obtained. The ratio for the agglutinin eluted at 37° was 1.813, and at 56°, 0.055. A similar result was observed with fractions obtained by density ultracentrifugation; the ratio was 1.22 with the light components and decreased progressively to 0.29 for the heavy fractions. (AH p-1)

D. Physiology

1. Physiological and biochemical characterization of uterine tissue.

(a) Quantitative characterization of uterine vascular permeability changes with estrogen. The uterine water and electrolyte changes occurring after estrogen administration have been thought to be due to an alteration in the permeability of the uterine capillary membranes. A quantitative method using the dye trypan blue was utilized to determine what proportion of the estrogen effects were due to increases in uterine blood volume and what proportion could be ascribed to changes in uterine permeability. At two hours after estrogen treatment, uterine blood volume had increased to a level three times that of the control. Increases in uterine permeability did not occur until four hours after the estrogen treatment. Permeability remained high at 6 and 8 hours, but by 12 hours had returned to control levels. (AH h5-8)

(b) Role of histamine in the mechanism of estrogen action in the rat uterus. Histamine has recently been proposed as being the mediator of estrogen action in the uterus, and studies were undertaken to determine whether histamine could reproduce the vascular permeability changes that estrogen produce in the uterus. Histamine caused a diphasic response in permeability, measured quantitatively by trypan blue accumulation in the uterus. A marked increase occurred at both 1/2 hour and 4 hours after histamine treatment. This type of permeability response is characteristic of tissue injury. A similar pattern is produced by burns and bacterial injection. Gross and histological examination demonstrated that histamine caused hemorrhage, stasis of blood in the uterus, and loss of the uterine epithelium. The pH of the histamine solution per se was not responsible for the uterine response. Estrogen caused an increase in uterine permeability at 4 hours but did not elicit the early 1/2 hour response. These results suggested that histamine was producing its effects primarily by causing tissue injury. (AH h5-8)

(c) Mechanism of estrogen action in stimulating glycogen synthesis in the uterus. One of the early metabolic changes induced in the uterus by estrogen is an increase in glycogen. While the mechanism is unknown, it has recently been proposed that the primary step in estrogen action depends upon a stimulation of some protein synthetic process. The present studies were undertaken to determine whether glycogen synthesis in the uterus could proceed while protein synthesis was inhibited. Cycloheximide, an antibiotic, was used to inhibit protein synthesis. It was found that cycloheximide itself was capable of stimulating an increase in uterine glycogen. Doses of 0.25 to 1.0 mg. of cycloheximide resulted in a 60% increase in glycogen in 4-1/2 hours and a 100% increase in 15-19 hours. Blood and uterine glucose levels were elevated and uterine water and weight increased following treatment. These observations suggest that the increase in the availability of the substrate, glucose, in the uterus stimulated glycogen synthesis. (AH h5-8)

2. Growth and development of mammary gland tissue. The role of the maternal placenta in mammary gland growth was determined. The presence of deciduoma, an artificial maternal placenta, induced mammary gland development at a level almost as high as in pregnant animals. Suspensions of either maternal, fetal, or whole placentae were injected into rats with various endocrine levels. These suspensions failed to cause increases in mammary gland growth above the levels already present in the recipient rats. The degree of mammary development achieved normally by pregnant rats at the end of gestation has not been attained by any of the combinations of endocrine levels and placental injections tested. (AH h5-1)

3. Inhibition of fertility by mechanical devices in the uterus.

(a) Plastic coils in ewes. A polyethylene plastic coil (pre-insertion diameter = 15 mm., length = 20 mm.) was inserted surgically into one uterine horn of each of 26 mature ewes at the Wisconsin Agricultural Experiment Station. The insertions were made on day-4 of the estrous cycle. The side of insertion was assigned randomly. On day-3, after the 1st or 2nd postoperative estrus, the new corpora lutea (CL) were marked with India ink and on day-6 the ewes were autopsied. The CL on the operative side were smaller ($P < 0.01$ for both the unilaterally and bilaterally ovulating groups) and often were more firm and pale than those on the nonoperative side. The observed length of the operative estrous cycle was shorter for the ewes which had ovulated on only the operative side than for those which had ovulated on only the nonoperative side. These data indicate that a plastic coil inserted in one uterine horn of the ewe results in a unilateral "inhibitory" influence on the CL. (AH h5-6)

At Beltsville, ewes with plastic spirals in the uteri were mated 2 to 4 weeks postsurgery and killed 3 days later. Eleven ova recovered from 11 control ewes were cleaving normally and contained numerous accessory spermatozoa. Sixteen ova were recovered from 16 experimental ewes. None was cleaving and no spermatozoa were seen in the zona pellucida. Thirteen of the 16 ewes had a spiral in 1 uterine horn only, and 5 uncleaved ova were recovered from oviducts opposite the uterine horn containing the spiral.

There was no evidence of infection in uterine lumens of experimental ewes. Ovulation, as determined by laparotomy, occurred at the proper time, between 20 and 30 hours after the onset of estrus. Ova were apparently fertilizable, since 2 ova transferred soon after ovulation from unmated experimental to mated control ewes were cleaving 2 days later. Reproductive tracts of 6 control ewes and 5 ewes with a spiral only in 1 uterine horn were flushed with saline solution 4-24 hours postmating. Between 2,800 and 142,000 sperm were counted in flushings from both oviducts of 5 of the 6 control ewes, but no sperm were found in flushings from either oviduct of experimental ewes. Uterine horns of experimental ewes contained relatively few sperm. The intrauterine spiral apparently interfered with the mechanisms involved in sperm transport, and this probably explains the failure of ovum fertilization. (AH h5-8)

(b) Plastic coils in cattle. Plastic coils were inserted into one or both uterine horns of parous Holstein cows. The cows were bred naturally or by artificial insemination at subsequent estrous periods. When plastic devices were present in both uterine horns, conception was prevented regardless of the method of breeding, as evidenced by more than 50 infertile estrous cycles with no pregnancies. It was observed that at 3 days post-breeding, 4 of 5 ova were fertilized after natural mating, but only 1 of 6 ova after artificial insemination. In addition, 6 cows with no coils in the uterus and 3 with a coil only in the uterine horn opposite the side of ovulation were fertilized by artificial insemination. Results to date suggest that intrauterine coils interfere more with ovum fertilization if cows are bred artificially than if bred naturally. Also, it appears that interference with fertilization in artificially bred cows occurs only if a coil is present on the side of ovulation. Five cows with a coil in one uterine horn were bred naturally when ovulation was to occur on the side opposite the coil. All cows were pregnant when killed at 60-70 days post-breeding, indicating that uteri with a coil in one horn were capable of supporting a pregnancy and that the intrauterine coil did not interfere with maintenance of the corpus luteum. (AH h5-8)

4. Hormonal control of the uterus.

(a) Porosity of the sheep endometrium. Endometrial vascular porosity was measured by the amount of intravenously injected trypan blue dye extracted from endometrium. Porosity was high in estrous ewes, intermediate in luteal-phase ewes, and low in ovariectomized ewes. The vascular response to histamine, injected into the uterine lumen, was greater in ovariectomized ewes than in estrous or luteal-phase ewes. It was also greater in ovariectomized ewes injected with progesterone than in those injected with estradiol or both hormones. This suggests an estrogen-dependent vasostabilizing mechanism in the endometrium. (AH h5-8)

(b) Neutrophilia in the rabbit. Effects of glucocorticoids on numbers and types of circulating leukocytes were investigated as a possible basis for intensification of induced leukocytic responses in the rabbit uterus. HCA was injected into rabbits and blood samples were taken for total and differential leucocyte counts. HCA injections were begun after blood samples were taken on the second day and continued daily for 3 days. HCA injections caused neutrophilia, lymphopenia, and eosinopenia. The neutrophilia may explain HCA enhancement of the leukocytic response to induced uterine infection. (AH h5-8)

(c) Leukocytic emigration in the rabbit. Rabbits were injected intramuscularly with hydrocortisone acetate over 2 to 4 days before inoculation of the uterine lumen with Escherichia coli. The corticoid caused a marked and consistent enhancement of the induced leukocytic response. The rabbits were injected intravenously with trypan blue 20 minutes before autopsy. Endometrial vascular permeability was measured by the amount of

dye extracted from the endometrium. The marked increase in endometrial vascular permeability that occurs during acute inflammation in ovariectomized rabbit uteri was not inhibited by the corticoids. As a further study, hydrocortisone was injected directly into the uterine lumen. It prevented the vascular response to bacterial infection observed in control rabbits, and to the corticoid suspension vehicle. (AH h5-8)

E. Nutrition

1. ~~B₁₂ synthesis in the rumen.~~ Two experiments measuring variations in the rumen synthesis of vitamin B₁₂ and its analogs have been conducted. In the first experiment, comparisons were made between the rumen contents of cows fed one of four diets, consisting of (1) chopped hay, (2) finely ground pelleted hay, (3) a hay and grain mixture, and (4) silage. In the second experiment, the cows were fed silage or hay, either ad libitum or restricted to maintenance level. The samples were analyzed by three methods, two of which measure both animal-active B₁₂ and microbiologically-active analogs, and the third of which measures only the animal-active form.

Both experiments indicate that the B₁₂ activity in the rumens of cows fed silage was 1.5 to 3 times that of cows fed chopped hay. The B₁₂ activity of cows fed hay-grain was decidedly lower than for any other group, while the activity from cows fed pellets was not greatly different from those fed chopped hay. Differences in animal-active vitamin B₁₂ accompanied differences in total vitamin B₁₂ activity. The vitamin B₁₂ activity was not significantly different between ad libitum and restricted feeding.

The vitamin B₁₂ potencies of the ingredients of the rations used in these experiments were markedly lower than the potencies of the rumen contents, and apparently could not account for the B₁₂ activity of the rumen contents. The lowest ratios between rumen contents and dietary ingredients occurred with the silage-fed cows but a marked increase in potency of the silage from the first experiment to the second was not accompanied by an increase in the B₁₂ potency of the rumen contents. The distribution between total and animal-active vitamin B₁₂ in the dietary ingredients resembled that found in the rumen contents only in the case of silage.

In studies with rats at Beltsville, results showed that several of the fatty acids produced in and absorbed from the rumen require vitamin B₁₂ for their metabolism, while others do not. Evidence was obtained indicating that vitamin B₁₂ is concerned in the metabolism of formic acid, which is produced in the rumen and is found there under certain conditions. Preliminary results appear to be consistent with the view that vitamin B₁₂ is involved in the metabolism of folic acid, which in turn is known to be concerned directly in the metabolism of formate. (AH h4-3)

2. B₁₂ in animal tissues. The concentrations of vitamin B₁₂ were determined in certain tissues of littermate rats fed a basal ration very deficient in vitamin B₁₂ or the basal supplemented with B₁₂. The tissues of the vitamin B₁₂-supplemented rats were 3.4 to 58.2 times higher in B₁₂ than those of the B₁₂-deficient rats. The kidneys showed the greatest response to vitamin B₁₂ supplementation. The testes likewise showed a fairly high increase. For most other tissues, the order of increase varied widely from one group to the other. The results support the concept of the kidney as the primary organ of storage of vitamin B₁₂, particularly of excess B₁₂.

Next to the kidney, the adrenals and the pituitary were the highest in vitamin B₁₂ concentration, followed by the heart. The other tissues examined were generally much lower in vitamin B₁₂ with the testes and seminal vesicles usually containing the smallest amounts. (AH h4-3)

3. Protein in B₁₂-deficient rations. Tests with rats showed that commercial isolated soy protein, supplemented with methionine, serves as a satisfactory source of protein in a vitamin B₁₂-deficient ration. Results were not significantly different from those obtained with Beltsville 10x-hot-alcohol-extracted casein. Without supplemental methionine, soy protein was inadequate for normal growth even when ample B₁₂ was present. A commercial "vitamin-free" casein contained significantly more vitamin B₁₂ than did Beltsville-extracted casein. (AH h4-3)

4. Protein source in A-deficient rations. Tests were conducted with laboratory rats to obtain information on whether a commercially available soy protein is equivalent to casein as the source of protein in vitamin A-deficient rations.

The soy protein, supplemented with methionine, and a specially prepared vitamin A-free casein were fed at equivalent levels. They were used as the sole source of protein in purified rations containing adequate amounts of all other known nutrients except that no vitamin A was added. The soy protein was found to be fully as deficient in vitamin A as the casein. When adequate amounts of vitamin A were added to the rations, the two proteins were equal in supporting maximal growth rate in rats. (AH h4-3)

5. Unidentified nutrients. Tests indicated that a depression in growth occurs in normal rats when their ration contains either sulfasuxidine or sulfathalidine. This depression in growth can be counteracted by feeding a substance such as fishmeal. Dried skim milk, dried yeast or soy protein are similarly effective. The depression in growth on the sulfa-containing ration persists for at least 8 weeks, but does not increase after the third week on the ration.

The sulfa drug, sulfathiozole, which is absorbed much more readily than the others tested, was also used. The growth depression was markedly greater and considerable mortality ensued. Fishmeal did not affect this condition but dried liver afforded considerable protection.

David et al. (J. Nutrition, 76:223, 1962) reported that an unidentified growth-promoting factor for chicks occurs in milk products, such as dried skim milk, whey and analyzed reagent grade lactose hydrate; lactose itself was thought not to be the active agent. In continuing studies, two separate experiments were conducted in an effort to ascertain whether an unidentified growth-promoting factor found in milk products was required by rats. With rats of the strain used and under the conditions of the experiment, no evidence was found that such a factor is required by the rat. (AH h4-1)

F. Rumen Function

1. Methanogenic bacteria. Work done this year has concentrated upon identifying a water soluble, rumen-fluid growth factor previously recognized as required for growth of Methanobacterium ruminantium. Objectives were to find efficient methods of purifying the active material and to attempt to characterize it. Many compounds known to be active as microbial growth factors were tested analytically for their ability to replace the rumen fluid factor. None of the compounds were successful replacements. Evidence suggests that none of the presently known growth factors for micro-organisms will replace the activity present in rumen fluid and that the compound will prove an unusual requirement.

Several strains of methanogenic bacteria have been newly isolated from the rumen. One strain, in particular, appears to be similar to the M. ruminantium strain in use. It does not require the rumen fluid growth factor and should prove useful to workers studying the biochemistry of methane production. (AH h2-3)

2. Electron transport and fermentation in rumen bacteria. Work during the year confirmed previous work in demonstrating porphobilinogen synthesis from delta-aminolevulinic acid by resting cells of Bacteroides ruminicola strain GA33. Porphyrin synthesis could not be demonstrated in resting cells; growing cells being required. Also confirmed was that the tetrapyrrole requirement of B. ruminicola strains results from lack or inactivity of enzymes synthesizing the tetrapyrrole nucleus.

Cytochromes of the b type were detected in Selenomonas ruminantium strains and in a strain of Butyrivibrio fibrisolvens and Bacteroides succinogenes. They behaved similarly to the cytochromes in B. ruminicola, being reduced by glucose and oxidized by oxalacetate, malate, fumarate, and CO₂, except for the cytochrome of B. succinogenes which was reduced by CO₂. A similarity in electron transport systems in these organisms, with the probable

exception of B. succinogenes, is suggested. The presence of a quinone, vitamin K₂, was demonstrated for the first time in rumen bacteria, in strains of B. ruminicola, S. ruminantium, and B. fibrisolvens. Neither cytochromes nor flavoproteins could be detected in a strain of Ruminococcus albus, suggesting that the electron transport system in this organism may differ from that of the other bacteria studied.

The presence of enzymes of the Embden-Meyerhof pathway of glucose degradation were demonstrated in strains of B. ruminicola and a strain of R. albus. No enzymes of the glucose monophosphate shunt pathway could be demonstrated, suggesting that it is not important in rumen bacteria. This agrees with indications by other workers that the shunt may not be of importance in the rumen fermentation. (AH h2-3)

3. Peptide utilization by Bacteroides ruminicola. Most strains of B. ruminicola can utilize peptide nitrogen but not free amino acid nitrogen for growth. The inability of B. ruminicola to take up free C¹⁴ proline was confirmed, and its inability to take up significant quantities of free C¹⁴ glutamic acid and free C¹⁴ valine was established. Studies on the kinetics of uptake of C¹⁴ labelled peptides by cells actively growing and synthesizing protein showed that non-protein-fixed C¹⁴ in the cells reached concentrations as much as 300 times, thus suggesting that the uptake process is energy dependent. Similar studies of cells whose protein synthesis was inhibited by chloramphenicol showed that the C¹⁴ which was concentrated in the cell leaked rapidly. This suggests that rapid intracellular hydrolysis of peptides occurs and that free amino acids cannot be held in the cell unless fixed into protein. Analysis of cell supernatants showed that the kinetics of release of free C¹⁴ proline from peptides was consistent with this hypothesis. Data showing that the fixation of C¹⁴ increases as peptide size increases is also consistent with the hypothesis. The question of whether or not enzymes are involved in uptake is crucial and investigations will continue.

The possibility that extracellular processes are occurring in competition with intracellular processes for peptides has been investigated. Preliminary results failed to show the presence of extracellular peptidases or deaminases. (AH h2-3)

G. Radioactive Fallout

1. Whole-body irradiation. At Cornell, studies on the effects of whole-body irradiation on farm animals have been completed, except for final analysis of the data. Some of the more significant physiological and pathological changes that occurred following irradiation were noted. Cows, goats, and sheep which were irradiated at 800 r or greater, died within three weeks after irradiation. In contrast, those irradiated at lower levels survived, and appeared generally healthy for 6 months after irradiation. Body temperature rose about 12 hours following irradiation

but soon returned to normal. Marked reduction in leukocytes occurred within 2 days. Gradual recovery began about 1 month later, but complete recovery did not occur within 6 months. Feed consumption and milk production generally decreased after irradiation but soon returned to the normal levels. The concentrations of the nuclides in milk usually increased for a period coinciding with decreased milk production. (AH h2-10)

2. Factors affecting strontium excretion in milk. Estimates of some of the important factors affecting strontium excretion in milk were made by utilizing results from cooperative studies at Minnesota, Iowa, and Utah. Under a stable intake of contaminated feed, the ratio of strontium to calcium in the milk is 0.1 times the ratio of strontium to calcium in the diet. The concentration of radiostrontium in milk declines by one-half in about 2-1/2 to 4 days after changing cows from a contaminated to an uncontaminated diet. On the other hand, when changing from an uncontaminated to a contaminated diet, the concentration of radiostrontium increases rapidly and reaches an essentially constant concentration in 5 to 6 days. These results are in close agreement with the laboratory tracer studies reported by other workers. The results were used in developing the background material for the Federal Radiation Council Report No. 7. (AH h2-10)

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AREA NO. 2: BEEF CATTLE -- BREEDING

Problem. Expression of each of the productive and carcass traits of beef cattle varies from breed to breed and between animals within each breed. The beef cattle producer is constantly striving to achieve excellence in one or more of these traits. Frequently his failure to choose the best animals for breeding stock for the most effective mating program results in less than maximum progress. Often the beef cattle producer does not know how to identify, evaluate, and utilize the existing variability to achieve his aim. Research information is needed on heritability of economic traits in beef cattle, genetic and phenotypic correlation between these traits, effectiveness of various selection and breeding programs, and assessment of traits most useful in beef cattle improvement. Basic information on cytology, inheritance of genetic abnormalities and genetic aspects of heritable biochemical and physiological characters will be required for a full understanding of applied problems.

USDA AND COOPERATIVE PROGRAM

The beef cattle breeding research in the United States has developed as a coordinated program of the USDA and the State experiment stations. It is a continuing program of both applied and basic research carried on by geneticists, animal physiologists, and animal husbandmen. Early efforts in the improvement of beef cattle through performance testing were made by the USDA at Miles City, Mont., and Beltsville, Md. With the advent of regional research, efforts by the State stations were greatly increased and the individual programs were coordinated through regional research projects in three of the important beef cattle producing regions. This joint activity has been and remains characteristic of beef cattle breeding research, and the resulting program is an integrated effort combining to the best advantage the resources of the State experiment stations and the USDA.

The regional project in the South is S-10, Improvement of Beef Cattle for the Southern Region through Breeding Methods. Much of this region is subtropical in climate and in many cases cattle used in other areas are poorly adapted. Environmental conditions adversely affecting survival, reproductive regularity and growth are encountered. Research includes active projects at 12 State stations and at the USDA stations at Jeanerette, La., Front Royal, Va., and Brooksville, Fla.

In the Western region the beef industry is largely geared to range conditions with many cattle shipped to areas of abundant grain supply for fattening. Ability to make maximum use of forage available on the range is an important consideration. These problems are studied through regional

project W-1, The Improvement of Beef Cattle through the Application of Breeding Methods. Research includes projects at 12 State stations and at the USDA station at Miles City, Mont.

Similarly, NC-1, Improvement of Beef Cattle through Breeding Methods, is geared to problems of the beef industry in the North Central region where beef is produced on farms with pastures of high productivity and ample grain supplies for feedlot finishing. Research includes projects at 12 State stations and at the USDA stations at Fort Robinson, Nebr., and Fort Reno, Okla.

The Federal scientific effort devoted to research in this area totals 15.7 professional man-years. Of this number, 1.3 are devoted to performance testing, 5.8 to genetics and interrelationships of performance traits, 1.7 to genetic-environmental interactions, and 6.9 to selection and systems of breeding.

PROGRAM OF STATE EXPERIMENT STATIONS

To a greater degree than many other research programs, beef cattle breeding research has developed as a coordinated program of the USDA and the State agricultural experiment stations. This has been achieved to a large degree by cooperative research activities under three regional beef cattle breeding projects. This coordinated program is described amply by the material appearing under the USDA and Cooperative Program. The several examples cited describe research of a cooperative nature, much of it conducted at the State experiment station locations. The reader is referred to this section of the Division report with these comments, and no attempt will be made to summarize the State programs separately.

The total research effort on beef cattle breeding research by the State agricultural experiment stations is 65.0 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

As compared to other disciplines, knowledge accumulates slowly in beef cattle breeding and genetics due to (1) low reproductive rates, and (2) high maintenance and operational costs per animal; i.e., per genetic unit. In the material which follows an attempt has been made to include only items on which specific analyses were completed or summaries made during the year.

A. Selection and Systems of Breeding

1. Effectiveness of selection for economically important traits. In Colorado, a study was completed on data from 14 Hereford inbred lines developed over a period of 18 years. The level of inbreeding increased rapidly in the formation of these lines and averaged 30% over the entire period. Estimates of genetic change were positive for feed efficiency and

negative for weaning weight and score in both sexes; and for final weight off test, average daily gain, and final grade among bulls. The level and rate of change of inbreeding appeared to have been real factors in the response of individual inbred lines to selection. (AH dl-16)

In a similar study at the Oregon Station involving one Angus and three Hereford lines, selection practiced for economic traits was positive for all traits studied. Automatic selection against inbreeding occurred on the sire side in conjunction with selection for increased performance. In general, performance increased early in the program, then leveled off, and subsequently declined. General improvement in all traits occurred only in the Angus line. (AH dl-19)

In a Nebraska experiment that is in the first generation of selection for single traits, foundation sires and their sons, selected on the basis of specific criteria, have sired calves in the same year. The selected sons produced progeny that were generally superior to the progeny of their sires in the primary selection criteria. Furthermore, the foundation sires were a highly select group. (AH dl-12)

2. Crossbreeding. Comprehensive analyses were made of the data from an extensive Fort Robinson, Nebr., crossbreeding experiment including the Hereford, Angus, and Shorthorn breeds. In the first phase of this experiment the three straightbreds and all reciprocal crosses among them were produced. Crossbreds and straightbreds were sired by the same bulls and were out of comparable cows. These studies included a total of 751 cattle from four calf crops sired by 16 Hereford, 17 Angus, and 16 Shorthorn bulls.

The effects of hybrid vigor were significant for most of the economic traits evaluated. A 3% greater calf crop was weaned in the crossbred than in the straightbred calves because of differences in early postnatal mortality. The heterosis effect on postweaning growth rate of heifers on a low level of feeding was greater than in steers on a growing-fattening ration. Heterosis tended to decrease with increasing age after approximately one year and was greatest on a restricted feed intake when comparing heifers with steers. After adjusting age at puberty for the effects of average preweaning and postweaning daily gains, approximately one-half to three-fourths of the heterosis effect on age at puberty (days) remained. Thus, there was a heterosis effect on age at puberty independent of its effect through average daily gains. The advantage of the crossbred steers in feed efficiency was small.

In net merit (value of the boneless, closely trimmed retail meat, adjusted for quality grade, minus feed costs from weaning to slaughter) the advantage of the crossbred steers over the straightbred steers was \$8.81 per carcass. This net merit difference is among the steers that lived to slaughter. The 3% advantage for the crossbreds in calf crop weaned was not involved in computing this difference.

For growth, feed efficiency, and carcass traits the heterosis effect was greater in the Hereford-Angus and Hereford-Shorthorn combinations than for the Angus-Shorthorn combination, while for age and weight at puberty, the heterosis effect was greatest for the Hereford x Shorthorn and reciprocal cross. In evaluating all traits for the effects of heterosis, it can be concluded that heterosis results in an increased rate of maturity.

The second phase of this experiment is now in progress. This involves the evaluation of the effects of hybrid vigor on fertility and mothering ability. That is, straightbred cows of the three breeds are being compared to their crossbred half-sibs when both are bred to the same bulls. For the two years (1963 and 1964) on which data have been collected, the advantage of the crossbred cows has been 17 and 6%, respectively, for calf crop weaned and 17 and 31 lb., respectively, in average weaning weight of calves at 200 days.

Milk production studies showed that crossbred cows gave no more milk than straightbreds immediately after calving but gave approximately 10% more milk in mid-lactation. (AH d1-12)

Ohio studies involving Charolais x Hereford and the reciprocal cross compared with their straightbred half-sibs from the parental breeds show a heterosis effect on growth rate.

Charolais, Brown Swiss, and Holstein topcrossed on Hereford have produced cattle with faster gains than the straightbred Herefords. However, the design of this experiment does not lend itself to an evaluation of the heterosis effects. (AH d1-10)

In Louisiana studies, crossbred calves grew somewhat more rapidly than purebred calves throughout the entire preweaning period. The preweaning growth curve was different for calves from British breed cows, as compared with calves from Brahman and Brangus cows. Calves from all four breeds of dam - Angus, Brahman, Brangus, and Hereford - grew at about the same rate for the first 140 days. At that time, growth rate of calves from British breed cows decreased while the growth rate of calves from Brahman and Brangus cows remained relatively constant. This may be due to greater persistency of lactation in Brahman-type cows. These data support the previous evidence that the effect of age of calf on weaning weight varies considerably from one breed to another.

Additional information on age of puberty in straightbred and crossbred heifers in this study indicates that breed crossing results in an appreciable amount of heterosis for this trait.

Also, at the Louisiana Station, a summary of calving dates and calving percentages by various sire-dam breed combinations indicates that Brahman bulls show some degree of selectivity as to the kind of cows they mate with.

Observation of the breeding behavior of Brahman bulls over the past 12 years has brought out the fact that some Brahman bulls definitely show strong preference for Brahman-type cows.

Several stations have been comparing different systems of mating for several years. The Georgia Station has completed one generation of a comparison of grading-up, crisscrossing, and three-breed rotational crossing. There has been little difference in the three systems in percentage of calf crop born, but due to a higher survival rate among both types of crossbreds, they have had a 3% greater net calf crop than the straightbred calves. (AH dl-3)

Another study comparing two-breed crosses with three-breed crosses indicates an advantage at weaning time of approximately 23 pounds in favor of the three-way cross steers. However, no differences were noted in postweaning performance. Smaller differences were obtained in heifers than in steers. A separate study showed a significant difference between breed crosses for weaning weight in favor of the crossbred calves. The crossbred cows in this study weaned a higher percentage of calf crop and remained in production longer than did straightbred Hereford controls.

The preliminary Miles City data indicate no consistent evidence of hybrid vigor for age at puberty in crossbred heifers as compared to straightbred heifers of the Hereford, Angus, and Charolais breeds. Data on bulls showed evidence of hybrid vigor in age at puberty for all breed crosses. There is evidence of hybrid vigor for birth and weaning weights among steer calves with the crosses exceeding the average of the parental breeds by 29 to 44 lb. in weaning weight. Crossbred steers also indicate substantial advantage over straightbreds in feedlot gain and feed efficiency. However, there is little evidence of hybrid vigor in preweaning or postweaning gain among the heifers. (AH dl-1)

The California data continue to indicate hybrid vigor for weights and gains but very little or no hybrid vigor for live and carcass grades or dressing percent. Based on palpation two months after the breeding season, the Angus x Hereford, Angus x Shorthorn, and Hereford x Shorthorn crosses indicated hybrid vigor of 10, 13, and 4%, respectively, for conception rates. (AH dl-40)

Facilities have been completed at a new experiment station in Hawaii and a crossbreeding study involving the Hereford, Angus, and Charolais breeds was begun during the 1965 breeding season.

3. Inbreeding and linecrossing. Adding to and, in general, confirming trends indicated in previous reports, studies on the effects of inbreeding on performance traits have recently been completed at Colorado, Oregon, New Mexico, Wyoming, and the U. S. Range Livestock Experiment Station, Miles City, Mont. It appears evident that increased inbreeding is associated with decreases in growth and live scores or grades. In general, the detrimental effects of inbreeding tend to decrease with increased maturity. However,

the magnitude and duration of the inbreeding effect appear to vary widely with the breed, line, location, sex, and level of environment. Inbreeding of dam has a detrimental effect on preweaning growth of calves and in many cases the effect is greater than the inbreeding of calf effect. (AH d1-16, AH d1-19, AH d1-2)

Preliminary results from the Miles City linecrossing study involving five inbred lines indicate that linecross bull calves have a 3% advantage in birth weight, 6% in 180-day weaning weight, and 3% in weaning score over contemporary inbred calves. The linecross bulls gained 3% faster in the feedlot and weighed 4% more at the end of the test. The linecross heifers weighed 3% more at birth, 9% more at weaning, scored 3% higher at weaning, and weighed 10% more at 18 months of age. Inbred line performance was indicative of performance in the crosses. (AH d1-2)

In a preliminary analysis of a similar study at Oregon, linecross calves (inbred dams) gained 0.09 and 0.12 of a pound per day faster, respectively, in the preweaning and postweaning periods than contemporary inbred calves. Linecross calves required 27 pounds less feed per 100 pounds gain than inbred calves. (AH d1-19)

The Arizona Station has initiated a project involving the testing of ten inbred Hereford lines developed at seven Western experiment stations. Information on topcrossing and general combining ability of the lines will be obtained and compared to controls produced by industry bulls on the same cow herd. (AH d1-46)

Preliminary results from crossing South Dakota lines of the Hereford breed with low levels of inbreeding indicate that an appreciable amount of heterosis may be obtained from specific crosses. The performance of some of these lines in top cross evaluations, when compared to outbred stocks, indicates that within line selection has been effective in improving traits that have an appreciable amount of additive genetic variation. (AH d1-13)

Comparison of inbred lines within breeds and between breeds - as well as to lines selected for type and growth - continues at the Front Royal Station. This project has proceeded far enough that bulls from the inbred lines, as well as the selection lines, will be topcrossed on unrelated cattle at Blacksburg, Virginia, for the Shorthorn lines and at Mississippi State University for the Angus lines. (AH d1-4)

B. Performance Testing

1. Carcass traits. Research on methods of estimating potential carcass quality in live animals has continued. In all three regions, use of ultrasonic devices on live animals has continued to give reasonably good estimates of carcass fat thickness. There are, however, differences among correlations from different groups of cattle. (AH d1-1, d1-9, d1-13, d1-36)

Utah has accumulated information on various methods of estimating the amount of fat in live animals. Tritium and N-acetyl-4 amino antipyrine are both quite effective, with tritium being the more accurate. These methods are very technical and require considerable equipment.

In a study evaluating the accuracy of predicting carcass composition, a multiple correlation equation containing the variables of carcass weight, rib eye area, single fat thickness at 12th rib, untrimmed round weight, edible portion round weight, and pelvic and kidney fat weight accounted for 94% of the variance in edible portion. Omitting the information on the round reduced this to 89% and the further removal of pelvic and kidney fat weight reduced it to 86%. Using carcass weight, rib eye area, and the average of three fat thickness measurements at the 12th rib accounted for 84% of the variability. Carcass weight alone accounted for 79%. (AHD1-13)

An analysis of data from the Nebraska crossbreeding experiment indicated an appreciable amount of additive genetic variation on carcass composition on a weight constant basis. This is not consistent with earlier preliminary findings which indicated that adjustment of carcass composition for weight effects removed most of the additive genetic variation in carcass composition. (AH d1-12)

In Michigan studies the relationship among carcass traits on data collected during the year appears to support the findings of previous years. Loin eye area was not a good indicator of percent preferred cuts ($r = -.27$). When carcass weight was held constant, the standard partial regression of percent preferred cuts on loin eye area was 0.19. The correlation between percent preferred cuts and carcass weight was $-.68$.

There continues to be a slight negative phenotypic correlation between adjusted percent preferred cuts and tenderness index ($r = -.24$).

For each of the last three years, the correlations between pounds of preferred cuts and carcass weight were above 0.95. Thus, selecting for weight of preferred cuts would be essentially synonymous with selecting for growth rate.

The correlation between percent round in the two halves was 0.88 and between percent loin in the two halves 0.65.

Live animal estimates of loin eye area and percent preferred cuts for two years have been analyzed. The appraisers estimated loin eye area more accurately than percent preferred cuts.

Carcass data on steers were studied to identify carcass attributes which contributed variation to carcass retail value. It is quite clear that most cattle can produce beef of satisfactory quality if a satisfactory method of feeding and management and length of feeding period are provided. In experiments where an effort was made to market the cattle as they reached

suitable market finish, variation in carcass weight was the dominant attribute in determining carcass value. Fat trim, the next in importance, ranked far below carcass weight. Weight of round (carcass weight constant) was the most useful of the wholesale cuts as an indicator of carcass value. (AH d1-10)

Several studies on production and carcass traits of bulls and steers have confirmed earlier results to the effect that young bulls excel steers in growth rate, feed efficiency and leanness of the carcass. Certain muscles from the steer carcasses were somewhat more tender when measured by either taste panels or the Warner-Bratzler shear. The steer carcasses had an advantage in carcass grade. (AH d1-9, AH d1-12, AH d1-32, AH d1-36, AH d1-40)

2. Growth rates. The Arkansas station has studied the relative association of feed consumption, initial weight, and indicators of carcass leanness with feedlot gains. A comparison of multiple correlations indicates that about 16% of the variance in gain was associated with round and loin weight, ribeye area, and fat thickness. On a constant weight basis, forequarter and chuck were significantly related to gain ($r = 0.33$).

Data on plasma cholesterol concentration were summarized by the Arizona station at four stages of development of range Herefords. Environmental conditions associated with year of birth may exert a significant effect upon cholesterol concentration in blood. No effect of age of dam was detected, and age of animal showed no consistent effect on concentration. There was no apparent relationship between plasma cholesterol concentration with subsequent concentrations or with growth traits. (AH d1-46)

Hematocrit values, total serum protein, percent serum albumin and globulins have been determined on yearling bulls by the Wyoming Station. Line differences were found in all variables except beta globulin, indicating possible genetic differences. However, none of the traits was related to performance up to yearling age.

Oregon reported that levels of enzyme activity between slowly and rapidly growing animals or between younger and older animals indicated that the animal's metabolism may be related to levels of enzyme activity. (AH d1-19)

Data were analyzed on 100-day and 205-day calf weights for calves raised on creep feeders and without creep feeders. The early weights appear to be good indicators of dam's producing ability and they also reflect weaning weight of the calves accurately. Correlations between age adjusted weights and average daily gains are so high that either contains practically all of the information on the growth of the calves. The phenotypic correlations between first weight and weaning weight for individual calves were 0.75 for creep fed calves and 0.82 for non-creep calves. The correlations between dam's producing ability as expressed in early weights and later gains of consecutive calves was 0.75 for creep fed calves and 0.66 for non-creep calves. (AH d1-10)

Postweaning growth records of steers indicate that initial weight and initial age were not important sources of variation for later gains unless the original variation in weight and age were quite large. Correlations between gains made in 28-day periods and total gain indicate gains in early periods tend to be slightly better indicators of total gain than those made in later periods. (AH dl-10)

One recently completed study reports correlation coefficients of preweaning average daily gain with weaning weight, 18-month weight, and 24-month weight of 0.82, 0.59, and 0.57, respectively, for Brangus and 0.82, 0.37, and 0.31, respectively, for Africander-Angus replacement heifers. The relationship of weaning weight to 18-month weight was 0.76, and the relationship to 24-month weight was 0.62 for Brangus and 0.88 and 0.78, respectively, for Africander-Angus. Preweaning average daily gain of steers - limited fed during the winter and then placed on postweaning feeding test - was significantly related to postweaning gain on test, lifetime gain, and final weight in both Brangus and Africander-Angus. (AH dl-6)

In work relating to feed consumption and other economic traits, the Arkansas Station reports that about 59% of the variance in gain is associated with feed consumption and initial weight. In this same study, bulls with heavier testicles were poorer converters of feed when put on a constant weight basis ($r = 0.44$); whereas, the bulls with more lean tissue - as indicated by cut weights and muscle area - were better converters of feed. In the same study, agonistic behavior and social rank indicated no breed differences in agonistic behavior. Chest depth and heart girth were significantly correlated with agonistic behavior within a group.

3. Cow size. Several S-10 studies indicate that cow size is heritable and may be related to production. Analysis of data from the North Carolina Station indicated that cows which were heavier 90 days before calving tended to produce heavier calves at birth and throughout the suckling period. These data suggest that this association is larger for younger cows and that the pattern of change in dam's weight appeared to be subject to herd and age effects. In the youngest class of dams, cows producing the faster-gaining calves showed smaller weight loss during the last 90 days of gestation and the first 60 days of lactation and higher gains throughout the remaining part of the lactating period. Older cows producing faster-gaining calves tended to have greater losses during the first 60 days of lactation and to gain more thereafter. (AH dl-23)

The effect of weight of dam on 180-day weight of Hereford calves raised at the Texas Station and on weaning weights of Angus calves raised in a privately-owned herd was studied. Hereford cows were weighed at calving and the Angus cows weighed at weaning. A linear relationship between calf weight and cow weight was observed in the Angus. A curvilinear relationship was observed in the Herefords.

An analysis of cow weight records from herds in Alabama, Florida, Georgia, Louisiana, North Carolina, South Carolina, and Texas showed all sources of variation, including location-year, breed within location-year, sire within sire, progeny within sire, age of dam and previous parity plus calving month for weight at calving, were statistically significant at the 0.05 level. These data indicated that cow weight increased with each year's increase in age up to nine years of age - the limit of these data - but the rate of increase was less with age. (AH d1-44)

4. Maintenance. On full feeding heifers consumed more energy per unit of metabolic weight than bulls. Efficiency of energy use by bulls and heifers appeared to be similar. However, heifers stored 29.2% of the net energy consumed and bulls 21.9%. This difference was apparently due to appetite. Correlation coefficients between live weight and carcass calories were 0.994 and 0.977 for heifers and bulls, respectively.

5. Selection indexes. Theoretical studies of probable effectiveness of selection for total net merit and for post-weaning net merit were made using single-trait and index selection. It appeared that selecting for final weight alone (452 days of age) would be 90% as effective in maximizing profit as selection for an index including pre- and post-weaning growth, feed efficiency and fat thickness (an indicator of carcass composition). Selection for weaning weight alone should be about 80% as efficient as selection for the index.

C. Genetics and Interrelationships of Performance Traits

1. Heritability of some performance traits. From an analyses of data (480 animals), estimates of heritability for some economic traits were as follows: average daily TDN consumption 0.46, percent retail product (boneless, closely trimmed meat from the entire carcass) 0.24, weight of retail product adjusted for age 0.65, fat thickness at 12th rib 0.50, quality grade of carcass 0.32, and net merit (value of retail product, adjusted for carcass quality grade, minus feed costs from weaning to slaughter) 0.55. (AH d1-12)

Heritability estimates were determined for growth and conformation traits for bulls and heifers in two lines of Herefords and for carcass traits of 80 randomly selected bulls. Low heritabilities were found for birth weight (5%), final conformation score (2 to 7%), final index (weight and conformation score) (15 to 24%), carcass conformation score of bulls (0.0), marbling score of bulls (0.0) and carcass grade of bulls (0.0). These estimates are not consistent with other studies for these traits. Medium heritability estimates were found for average daily gains of heifers (39%), left side carcass weight of bulls (40%), fat thickness of bulls (36%), trimmed primal cuts of bulls (32%), trimmed wholesale cuts of bulls (39%), and retail yield of bulls (42%). Higher than usual heritability estimates were found for average daily preweaning gains (89%), 210-day weight (80%) and

210-day weight adjusted for age of dam (65%). Ribeye area of bulls (72%), and total trimmed fat of bulls (54%) were found to be highly heritable. (AH dl-42)

A study on predicting the producing ability of range cows using weights and gains taken throughout life was reported by the Miles City station. Heritability of producing ability was estimated to be 0.45 based on an average of 3.2 calves per cow. Phenotypic, genetic, and environmental correlations of weights and gains from birth through maturity with producing ability were small and were not accurate indicators of producing ability. Eighteen-month weight was the best single predictor of producing ability both genetically and phenotypically. (AH dl-1)

Data from a Louisiana study showed large although not significant differences in calving percent between breeds and crosses.

The Florida station has found heritability estimates of calving percentage to be in the neighborhood of 0.3 to 0.6, considerably higher than previously reported.

2. Genetic correlations. Data from 480 animals show high positive genetic correlations between different periods of growth and weights at different ages. The correlations reveal that genetic improvement in percent retail product will likely be difficult if quality grade is improved or maintained. Also, these results indicate that percent retail product is of questionable value as a selection objective. (AH dl-12)

Results of heritability and genetic correlation studies of carcass data indicate that selection for growth rate would result in a greater increase in yield of separable lean than would selection for composition itself due to the high genetic correlation between lean and growth and the high heritability of growth. (AH dl-13)

3. Genetic-environmental interactions. Work on genetic-environmental interactions is being continued in two studies - one a cooperative effort between the Stations at Brooksville, Florida, and Miles City, Montana; the other at the North Carolina Station. Data at the North Carolina Station indicate that sire-location interactions or evidence of genotype-environmental interactions are small. There was a large contrast this year between the calving percentages of the Miles City cattle transported to Florida, as compared to cattle of the Miles City line raised at Florida and the Hereford cattle that have been at Brooksville for several generations. (AH dl-41), (AH dl-23)

4. Dual-purpose cattle breeding. A herd of Milking Shorthorn cows (not part of any regional breeding project) has been maintained under a cooperative arrangement with the Minnesota Agricultural Experiment Station with the general objectives of (1) improving genetic capacity for milk

production as rapidly as possible, and (2) observing changes, if any, in beef production qualities of male calves as genetic milk production level of the herd increases. To this end, cows have been inseminated with semen of progeny-tested bulls carrying the highest apparent genetic milk production potential available either in the United States or abroad. Steer calves have been fed out with Holstein and Herefords and their carcasses evaluated.

Since 1959 the rolling Dairy Herd Improvement Association herd average has fluctuated somewhat but has shown a rather consistent rise from a low of 5,715 lb. of milk and 222 lb. of butterfat to its present level of 9,077 lb. milk and 341 lb. butterfat. Eighteen daughters of the two best bulls used (both New Zealand animals) have freshened and preliminary information shows an apparent superiority of approximately 2,100 lb. milk and 60 lb. butterfat for their daughters over herdmates.

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AREA NO. 3: BEEF CATTLE -- PHYSIOLOGY

Problem. Reproductive performance is the largest single factor affecting net profit in a cow-calf operation. Increasing the reproductive performance of a beef cow herd will result in more pounds of calf weaned per cow bred. More cows will wean a calf, and more cows will calve early in the calving season when reproductive performance is improved. Poor reproductive performance is largely the result of: (1) cows not showing heat early in the breeding season, (2) cows not conceiving at first service, and (3) calf losses occurring at or near calving. The physiological mechanism responsible for the onset of estrus and conception must be explored further and methods of controlling these adequately must be found if reproductive performance is to be improved.

USDA AND COOPERATIVE PROGRAM

The program at present is concerned with methods of altering, improving, or controlling reproductive performance by hormonal and nutritional methods and determining basic information on hormonal relationships during the estrous cycle. The program has approximately 144 cattle involved at Jeanerette, La.; 500 at Fort Robinson, Nebr.; 110 at Miles City, Mont.; 140 at El Reno, Okla.; and 136 at Beltsville, Md. Some reproductive information is also obtained on cattle involved in other studies at all of these locations except Beltsville. Major studies involve: (1) relationship between nutrition and reproductive performance at Miles City, Fort Robinson, El Reno, and Beltsville; (2) hormonal control of the estrous cycle at Fort Robinson; (3) causes of maintenance and regression of the corpus luteum at Fort Robinson; (4) induction of twin ovulations at Miles City; and (5) causes of calf losses at or near calving at Miles City and Fort Robinson.

The Federal scientific effort devoted to this area of work totals 3.1 professional man-years, all of which are devoted to physiology of reproduction.

PROGRAM OF STATE EXPERIMENT STATIONS

Research on physiological problems related to beef cattle production is conducted at many stations. These studies include the effect of controlled temperature and hormones on reproduction in heifers of both Brahman and British breeding, the nature of sterility in animals which leave herds because of failure to reproduce, and research designed to more clearly define fundamental principles related to ova transfer and to develop a technique for collection and transfer of ova without surgery. Investigation of physiological effects of various hormone substances, and development of simplified methods for bringing groups of animals into estrus within a short period is the objective of other research. Basic studies will determine the site of maturation of sperm, and if proven to take place in the uterus, attempts will be made to isolate the material responsible for maturation. A portion of this

work is conducted under the W-49 regional project "Physiological Mechanisms Affecting Fertility in Cattle."

Research in environmental physiology includes developing biological measures of response to environmental stress under controlled conditions, procedures for measuring environmental responses under field conditions, and the effect of nutrient restriction following weaning on the growth of heifers and upon subsequent lifetime production. A portion of this work is conducted under W-46 regional project "The Effects of Environmental Stresses on Range Cattle and Sheep Production."

Other studies seek to explain the action of hormone compounds in promoting growth and the effect of levels of milk and forage intake at different periods on gain and weaning weight of beef calves.

The total State effort devoted to physiology of beef cattle is 20.5 professional man-years. An additional 5.0 professional man-years pertains to Area 1 and is included therein.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Physiology of Reproduction

1. Nutrition and reproduction. Three experiments are underway in drylots. Calving difficulty was increased in heifers fed moderate levels of TDN (8.0 lb.) compared to heifers fed low levels of TDN (4.3 lb.). However, no difference in losses at calving were noted. The length of the interval from calving to first heat was longer in cows on low levels of feed prior to calving. However, the proportion of cows that became pregnant in a 60-day breeding season did not differ. Feeding cows high levels of feed after calving did not appear to improve reproductive performance. This is in contrast to previous years' results. (AH d1-37, AH d2-22)

The influence of various levels of supplemental range feeding on reproductive performance is being studied at four stations. Results indicate that the nutritional level supplied by pastures in the Gulf Coast region does not support adequate reproductive performance. Low levels of winter supplementation in Oklahoma led to a longer interval from calving to first heat. Data from Fort Robinson indicate that cows supplemented after calving returned to heat much sooner than cows not supplemented. Data from Miles City indicate little difference in reproductive performance between heifers receiving 8 pounds of supplement and those receiving no supplement. Thus, results vary from area to area.

Two studies have been conducted regarding the effect of nutritional level on age at puberty. In Louisiana and Nebraska the low level of nutrition delayed the onset of puberty in straightbred heifers more than in crossbreds. Little or no difference in puberty was noted between different breeds of heifers on high level of feed at Nebraska but Brahman heifers had delayed puberty in

Louisiana even on high levels of feed. (AH d1-37, AH d2-12, AH d1-33, AH d2-34)

Studies conducted at Front Royal, Va., and Brooksville, Fla., have not shown beneficial effects on calf survival or subsequent conception rate from supplemental vitamin A feeding or injecting to normally managed pregnant beef cows. (AH d3-2, AH d1-4).

2. Losses at or near calving. Most calf death losses occur at or near birth. Many of the losses are the result of delayed or difficult parturition. Losses have been higher in straightbred than crossbred calves. (AH d1-30, AH d1-33, AH d1-37)

3. Puberty. Results are available from Jeanerette, Miles City, and Fort Robinson. Results from Fort Robinson indicate that crossbred heifers reach puberty at an earlier age while data from Miles City fail to show a heterotic effect on age at puberty. Age at puberty in bulls showed a small difference in favor of crossbred bulls. (AH d1-33, AH d1-37, AH d2-34)

4. Control of estrus. In a series of trials it was demonstrated that estrus could be successfully synchronized by feeding a new synthetic progesterone-like compound for nine days, followed by a small injection of a synthetic estrogen. Results indicate that cows suckling calves can be successfully synchronized by this treatment if they are cycling prior to start of treatment. Fertilization rate, length of heat, and time of ovulation in heifers synchronized by this method did not differ from control heifers. (AH d1-37)

Causes of maintenance of the corpus luteum have been explored further this past year. The regression of the corpus luteum noted following small, daily injections of estradiol 17-beta were reversed by injection of HCG. However, equine LH, FSH, or a combination of the two were ineffective in this regard. Daily injections of 500 I.U. of HCG also maintained the corpus luteum to the 24th day of the estrous cycle. (AH d1-37)

5. Fertility data from breeding herds. Data from Fort Robinson and Jeanerette indicate that reproductive efficiency is increased in crossbred cows. More crossbred than straightbred cows settled on first service and more crossbred cows became pregnant. The interval from calving to first heat did not differ between straightbred and crossbred cows at Fort Robinson but did at Jeanerette. Breed of sire has also been shown to affect pregnancy rate at Jeanerette with Angus bulls having a higher pregnancy rate than Brahman bulls. (AH d1-30, AH d1-37)

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AREA NO. 4: BEEF CATTLE -- NUTRITION AND MANAGEMENT

Problem. Producers of beef cattle need improved feeding methods which will result in optimum pasture and feedlot gains, reduced feed consumption per pound of beef produced, optimum reproductive rates, and desired carcass qualities. To meet these needs basic nutritional information is required such as: When should beef animals be fed for maximum gains and when for more limited gains? What nutrient combinations produce rapid growth of muscle with a minimum of fat deposition? How may breeding animals be economically raised that will be capable of a high level of reproductive performance over a long lifetime? What are the nutritive contributions made by range and pasture and what supplementation is required when each is used? Research is also needed on the relationship between animal production and type of shelters and equipment, feeding systems, and methods of increasing labor efficiency.

USDA AND COOPERATIVE PROGRAM

This is a continuing program carried on by nutritionists, biochemists, and animal husbandmen on basic and applied problems related to feeding and management of cattle for beef. The work is in progress at Beltsville, Md.; in cooperation with State experiment stations at federally owned stations in Miles City, Mont.; Fort Robinson, Nebr.; Fort Reno, Okla.; Jeanerette, La.; Brooksville, Fla.; Front Royal, Va.; Newell, S. Dak.; in cooperation with State experiment stations at Tifton, Ga.; and College Station, Tex.

There are contracts totaling \$251,754 with the California, Kentucky, Florida, Wisconsin, and Nebraska Agricultural Experiment Stations. These projects are concerned with the methods of feed preparation and level of grain in the ration, the sites and amount of starch utilization in the ruminant digestive tract, ration components which control feed intake, graded levels of energy intake upon reproductive performance in beef cattle and management of males of beef and dairy breeding for beef production. These projects are for either 3 or 4 years (1964-1967 or 1968), and their basic purpose is to determine the potential for increased utilization of grains for beef production.

There is one grant involving Public Law 480 funds with the Agricultural College in Poznan, Poland. The project is to determine the trace mineral content of forages as affected by stage of growth and methods of harvesting and storing. The project is for a five-year period (1963-1968) and is supported by \$47,311.66 equivalent in Polish zlotys. Another grant with the Institute of Biochemistry and Biophysics in Warsaw, Poland, is to determine the metabolic pathway of protein biosynthesis in the liver microsomes of the guinea pig. The project is for five years (1963-1968) and is supported by \$60,411.46 equivalent in Polish zlotys.

The Federal scientific effort devoted to research in this area totals 12.3 professional man-years. Of this number 4.1 are devoted to digestion and metabolism; 1.5 to concentrates; 1.4 to forage preservation and utilization; 0.7 to nutrient requirements; 3.0 to range and pasture management; 1.1 to management practices; and 0.5 to behavior.

PROGRAM OF STATE EXPERIMENT STATIONS

The States have research in progress on the basic functions of the rumen, particularly the animal-feed interrelations which are responsible for bloat efficient feed digestion, and the synthesis of essential nutrients. (Additional investigations of rumen function appear in problem area #1.)

The basic requirements of beef cattle for specific nutrients, their metabolism, interactions, and availability in feeds are receiving attention at a number of stations. Some of the topics being investigated are: (1) The requirements, metabolism, and interactions of the many major and trace nutrients; (2) the effect of feed additives or implants upon growth and feed efficiency; (3) the relation of nutrients to metabolic disorders; (4) the toxicity of molybdenum and fluorine; (5) the value of irradiated feeds and assimilation of fallout products; (6) the use of roughage concentrate ratios and chemical regulators for feed intake control; (7) the effect of physical form of the ration upon nutritional value; (8) a reevaluation of the vitamin A requirements and factors affecting them made necessary by apparent deficiencies on rations with ample carotene based on earlier standards.

The efficiency of feed use is being improved through investigations of concentrate and forage feeding. The problems and advantages of all-concentrate or high-concentrate feeding have high priority at this time. The comparative values of various kinds and combinations of feeds and the effect of different physical forms (chopped, pelleted, etc.) are being studied. There is considerable emphasis on development of methods for evaluation of forage crops. Four cooperative regional research committees (NC-64, NE-24, S-45 and W-34) have all or a significant part of their project devoted to this evaluation.

Management problems are being investigated. The main topics are combinations of pasture and drylot feeding; maximum use of pasture throughout the season, especially extending the period by using late fall and early spring pasture crops; supplementation needed when low quality roughages are fed; and creep feeding vs. non-creep feeding of calves.

The State stations have 143 professional man-years devoted to beef cattle nutrition and management.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Digestion and Metabolism

1. Digestion and balance studies. When comparing rations containing 50% cracked corn and 50% sweet potato trimmings, steers consuming the sweet potato ration gained less weight (0.79 vs. 1.03 kg./day) and had lower grading carcasses (low good vs. low choice). Dry matter and crude protein were less digestible in the ration containing the sweet potato trimmings. It may be calculated from these data that sweet potato trimmings contain approximately 80% of the nutritive value of corn. (AH d2-14)

The effects of source of nitrogen and source of carbohydrate on nitrogen utilization were studied using purified diets. Digestibility of nitrogen from urea was greater than nitrogen from isolated soy protein, and starch promoted significantly greater digestibility of nitrogen than did a combination of starch and cerulose. Due to lowered urinary losses, nitrogen retention was greater for the isolated soy protein rations. Feeding the starch ration resulted in greater ruminal molar percentages of acetate and lower percentages of butyric plus higher volatile fatty acids. Information such as this is useful in predicting response differentials by cattle when fed different cereal grains or nitrogen supplements. (AH d2-37)

2. Salivary secretion. Salivary flow was not altered by varying the source of nitrogen (urea vs. soy protein) or carbohydrates (starch vs. cerulose) in purified diets fed to steers. Rate of flow was greater and buffering capacity of the saliva was less during the p.m. than during the a.m. collections. Ruminal a.m. pH was higher and ruminal ingesta weight, volume, and dry matter content were less when steers consumed rations containing urea as the nitrogen source. (AH d2-37)

Daily salivary secretion was 33.5, 45.2, 52.0 and 54.1 liters when steers averaging 350 kg. in weight were fed intakes of .8, 1.4, 2.0, and 2.6% of empty body weight, respectively. Although rate of salivary secretion was higher during intervals when the steers were eating, the response to level of feed intake during eating and resting intervals was essentially the same. (AH d2-37)

Steers were fed 89% or 25% roughage rations as pellets or as coarsely ground mixtures. Resting salivary secretion was greater when feeding the coarsely ground 89% roughage ration (2.0 liters per hour) than when the other rations were fed (1.4 to 1.6 liters per hour).

An adequate flow of saliva is required for proper digestion, and information such as that presented above should lead to feeding and management procedures favoring optimum digestive function. (AH d2-37)

3. Metabolic diseases. In cattle studies at College Station, Texas, in cooperation with the Texas Agricultural Experiment Station when cattle were fed out at various locations in Texas and when cattle and feed were from common origins, location apparently did not play a major role in urinary calculi formation. (AH d2-31)

At the Beeville, Texas, Substation cottonseed hulls, as the source of roughage, produced the greatest number of steers with uroliths and the largest quantity of stones. Approximately 50% of the steers which developed uroliths had received cottonseed hulls in the diet. Steers consuming flax shives as a roughage had the smallest incidence of uroliths followed by ammoniated rice hulls, rice hulls, and an all concentrate ration in that order. (AH d2-31)

Six percent NH_4Cl was added to 29% protein range cubes and fed to 50 weanling calves under normal range management conditions at a private ranch in Nebraska. While consumption was limited to a maximum of 0.75 lb. of cubes daily, the level of NH_4Cl (.07 oz.) was sufficient to decrease the incidence of urinary calculi as compared to a group of 50 calves not receiving the treatment (one case in the treated group as compared to four in the untreated group). (AH d2-31)

In field trials involving 1009 beef cows (S. Dakota) one loss occurred among 505 cows supplemented with magnesium (6 g./day) and calcium (12 g./day), while 18 cases of grass tetany (11 deaths) occurred among the 504 unsupplemented cows. (AH d2-35)

4. Pesticide residues. In a feeding experiment at Tifton, Georgia, corn silage containing 1 to 7 ppm. of dimethoate was fed to beef steers. No effect on blood cholinesterase activity was observed. Feeding silage produced from corn treated with technical grade dimethoate (7% impurities) caused a reduction in feed intake and seemed to impair animal health. This was not true when corn was treated with pure dimethoate. (AH d2-32)

There was no apparent effect from exposure to the pesticides Diagonon and Cygon on ruminal microbial gas production. Preliminary observations do not suggest a differentiating effect of the pesticides on the protozoal population (AH d2-32)

Current cooperative studies with Pesticide Chemical Research Branch on malathion and DDT are concerned with the dissipation of malathion and its metabolites after a massive dose or during low level chronic dosing. Tissues being studies included fat, liver, and blood. Similar studies are being initiated with DDT, except that distribution of the chemical among the fat depots and muscle will also be investigated. (AH d2-32)

A cooperative pesticide study with the Virginia Experiment Station has been initiated at Front Royal, Virginia. Rate of accumulation, techniques, and management procedures which may change the rate of dissipation of the pesticide (heptachlor) from the body tissues of steers are being studied. Mature beef cows are being used to study the effects of heptachlor in the diet (contaminated alfalfa) of pregnant and lactating cattle. Presence of the pesticide will be checked in the cows, the newborn calves, the milk, and nursing calves. (AH d2-43)

5. Microbiology. The effect of implanted diethylstilbestrol (DES) on the rumen microbial population in steers fed 90% corn vs. 90% wheat was examined. Two out of ten steers fed wheat contained ruminal ciliated protozoa (Holotrichs) but none were found in the ruminal fluid of steers fed corn. The number of protozoa did not appear to be related to DES treatment. Total viable counts were higher in steers fed corn and lower in steers fed wheat when DES was implanted. Presumptive identifications of the predominate strains of ruminal bacteria present by treatments are being made. (AH d2-26)

An "artificial rumen" continuous culture used to study the effect of pH on the ruminal microbial ecosystem indicated that at decreased pH's the bacterial cellulolytic activity is affected to a greater degree than the amylolytic activity, that the bacterial population changes qualitatively with pH changes, and that DNA may be a more reliable parameter to measure microbial population quantitatively than viable counts. (AH d2-26)

When steers were switched from a 75:25, concentrate to roughage, diet to a purified diet containing urea as the only nitrogen source, the following ruminal changes occurred: bacterial counts, molar percent of butyric plus higher acids, total concentration of volatile fatty acids and ammonia concentrations increased while protozoal counts, molar percent of acetic acid, and pH decreased. (AH d2-26)

B. Nutrient Requirements

1. Reproduction. An identical twin Angus cow weighing 930 lb. gave birth to a normal 51 lb. heifer calf, after being raised since weaning on a protein-free diet. A purified diet containing urea as the only nitrogen source was fed during this time. The 1030 lb. co-twin was fed an equal amount of nitrogen and calories in a diet of conventional feedstuffs and gave birth to a 60 lb. heifer.

Currently, bull and heifer calves are being weaned at 82 days of age and placed on purified diets to further study the dietary needs of cattle for growth, reproduction, and lactation.

Different levels of urea in conventional diets are being used to study the long-term effects on the reproductive performance of 12 sets of identical twin beef females. Rations containing none, 1/3 and 2/3 of the total protein equivalent as urea are being compared. After 363 days on test, the gains have been approximately the same for all treatments. The heifers are bred when the lightest twin of a pair reaches 600 lb. (AH d2-22)

The Polish studies on the reactions in liver microsomes during in-vitro protein biosynthesis indicate that Asp-sRNA did not abolish the inhibitory effect of oxaloacetyl-sRNA Asp. (E21-AH-7)

C. Concentrates

1. High concentrate rations for finishing steers. Yearling steers were fed for 98 days rations containing more than 90% corn, wheat, or combinations of these grains. Steers fed all corn or 2/3 corn and 1/3 wheat gained faster than steers fed 2/3 wheat and 1/3 corn or all wheat. Daily gains were 3.1, 2.9, 2.5, and 2.6 lb. for these groups, respectively. Carcass data were similar for all groups. Ruminal samples taken shortly before slaughter from the cattle receiving 2/3 and all wheat were more acid and contained more VFA and NH_3 than samples from steers on 2/3 corn or all corn. Determinations of the plasma amino acids showed that the cattle fed the wheat ration had less aspartic acid, serine, and leucine but more lysine and urea than cattle fed the corn ration. Implantation with 24 mg. stilbestrol resulted in a greater concentration of plasma glycine.

In a 112 day feeding trial, steer gains were depressed when 5% soy oil was added to and 1.5% urea deleted from a ration of more than 90% cracked corn during the last 56 days of the test. Ruminal ammonia concentrations and rib eye areas were less when the soy oil was added and the urea deleted. (AH d2-37)

At Fort Reno, Oklahoma, a basal ration of barley supplemented with soybean meal, calcium, and vitamin A was fed. Cobalt supplementation tended to increase weight gain, feed consumption, carcass grade, marbling score, and rib eye area. Zinc supplementation alone did not affect growth performance and carcass traits. Combined cobalt-zinc supplementation interacted in such a way on feed/gain and rib eye area as to suggest that zinc may be a limiting trace mineral when the cobalt level is adequate. These results indicate that an "all-barley" type fattening ration is deficient in cobalt and perhaps marginal in zinc.

When feeding rations of about 70% milo to fattening calves, replacement of cottonseed meal with urea decreased gains but improved feed cost per unit of gain. The addition of corn oil to a milo-urea ration did not improve performance, but the addition of a complex vitamin-trace mineral mixture plus corn oil did improve the rate of gain of calves. Trials with identical twin calves fed high milo rations indicated that neither the addition of urea to cottonseed meal nor the replacement of cottonseed meal with soybean meal was of benefit. The replacement of cottonseed meal with fish meal or the addition of copper to a urea containing ration improved rate and efficiency of gain. (AH d2-37)

2. Finishing cattle. When feeding "high" urea rations, based on snapped corn, to beef calves (400 lb.), alfalfa meal appeared to be necessary but was of no advantage when feeding yearling beef steers (700 lb.) on similar rations. The final decision to use urea will depend upon the comparative cost of all feed ingredients. (AH d2-14)

The effects of various levels of roughage in rations for fattening steers were studied in two experiments at Tifton, Georgia. Roughage levels varied from 10 to 50% of the ration. There was no advantage to feeding a small amount of unground hay. Daily gains were not markedly or consistently affected by level of roughage in the ration. In another experiment it was observed that full-fed steers perform better than steers restricted to 92.5 or 85.0% of the intake of steers which were full-fed. (AH d2-14)

Wintering rations ranging from 0 to 100% steam rolled barley were fed to beef calves in studies at Newell, South Dakota. The calves offered all hay were allowed to feed ad libitum, and the barley was substituted for the hay on the basis of its available energy content. Gains during the winter and subsequent summer (pasture) were similar for all groups. The results indicate that beef calves can be wintered satisfactorily by substituting barley for part or all of the hay in wintering rations. The barley was worth about twice as much per lb. as a 50:50 prairie hay-alfalfa hay mixture.

When rations containing from 50 to 95% barley were fed to finishing steers, daily gains increased somewhat as the amount of grain in the ration increased (2.5 to 2.7 lb./day). There were no differences in carcass grades when the steers were fed to a common slaughter weight.

Restricting feed intake to 85% of full feeding decreased gains and outside fat cover but did not consistently affect carcass grades and rib eye areas. (AH d2-35)

Studies on cereal grain utilization, as affected by method of preparation were conducted at Davis, California. Feed consumption was reduced when grains (corn, milo, and barley) were rolled after 1 1/2 min. of steaming at 60 pounds per square inch (psi). Gains were improved when the grains were rolled after 1 1/2 min. of steaming at 20 psi. Although it was not conclusive, the response appeared greater at the 60% than at the 40 or 80% grain levels. The response in feed efficiency paralleled the response in gains. (AH d2-38)

Studies conducted with steers at Kentucky indicate that the quantity of starch passing into the abomasum increases with increasing levels of starch intake. Thus, post-ruminal starch digestion assumes greater importance in overall starch utilization as dietary starch intake increases. (AH d2-39)

D. Forage Preservation and Utilization

1. Utilization of coastal bermudagrass. The final years' study on six systems of utilizing coastal bermudagrass indicated trends similar to those reported for the earlier trials conducted at Tifton, Georgia. For the three years, the average daily gains for the various systems were: continuous grazing, 1.31 lb.; rotational grazing, 0.89 lb.; strip grazing, 0.86 lb.; feeding pellets, 1.76 lb.; feeding dehydrated hay, 1.48 lb.; and feeding fresh green chop, 0.81 lb. Feed consumption figures are correlated with gains. (AH d2-42)

2. Feeding value of pelleted feeds. See section A, 2.

E. Range and Pasture Management

1. Range supplementation studies. At Brooksville, Florida, cows given injections of 6 million units of vitamin A in November and in April showed no advantage in 205-day weight, calf survival, or pregnancy rate when compared to cows receiving no vitamin A injections. (AH d3-2)

Range management studies at Miles City, Montana, continue to indicate that calf gains during the spring period (4/27 to 6/4) are higher on introduced grass pastures of crested wheatgrass and Russian wild-rye than on native range. In addition, stocking rates (animals/acre) are also greater on the introduced pasture. Percent pregnant at the end of October was excellent for cows pastured during the spring on either the native range (92.3%) or the introduced pastures (100%). (AH d3-1)

At Tifton, Georgia, preliminary studies indicated that steers grazing oats and rye (January through March) outgained (2.1 vs. 1.1 lb./day) steers grazing wheat and barley. Compensatory gains were made in drylot by the steers previously grazed on wheat and barley but estimated feed costs per pound of gain were greater. (AH d2-42)

Steers grazed on oats and then millet averaged 1.8 lb./day gains in studies conducted during three years. (AH d2-42)

Summarizing long-term studies conducted at Fort Reno, Oklahoma, it was noted that adequate nutrition is just as critical in the lactating two-year-old as in the yearling heifer. Earliness of calving and promptness of rebreeding of two-year-old heifers depends largely on the level of nutrition provided during the critical wintering period. (AH d2-36)

Studies of the cumulative influence of level of wintering on the lifetime performance of beef females through five calf crops were conducted. This research indicates that rather than select a level of wintering for the lifetime of the cow, consideration should be given to the life cycle feeding approach in which higher levels are used during growth and development of the female followed by lower levels after the cow has reached maturity. (AH d2-36)

F. Management Practices

1. Management of cattle and pastures for beef production. Winter feeding experiments at South Dakota indicate that when wintering steer calves, there is an advantage in feeding for gains of 1.5 lb./day instead of 1.0 lb./day. This advantage is apparent in total gains, whether the cattle are subsequently fed in drylot or pastures. Steers receiving up to 20 lb. of sorghum silage per day performed as well as steers receiving hay as a source of roughage.

Total winter and summer gains of steers implanted with 12 mg. of stilbestrol in the fall (shortly after weaning) or 24 mg. in the spring compared favorably. There was no advantage to implanting in both fall and spring. There was an advantage to implanting (12 mg.) when steers were subsequently placed in the feedlot. (AH d2-35)

Wintering steer studies at Tifton, Georgia, demonstrated that the feeding value of 5-week-old bahia and coastal bermudagrass hays are similar. The 5-week cuttings of hay support better steer gains than that of either of these hays when cut at 8 weeks of age. (AH d2-42)

The trace element study of soils and forages in Poland continues to show that there are great differences in microelement content of forages depending on species, stage of vegetation and geographic area. (E21-AH-6)

Studies designed to identify and define factors associated with meat quality as affected by maturity and nutritional treatment have been initiated at Beltsville, Md. These studies are being conducted in cooperation with Market Quality Research Division. Beef calves are being (1) full fed, (2) fed to gain about 1 lb./day, or (3) fed to gain about 1 lb./day until six months prior to slaughter and then full fed. Steers within each of these groups will be slaughtered at ages of 6, 12, 18, 24, 30, 36, 48, 60, and 84 months. Physical, chemical, and organoleptic evaluations will be conducted on the carcasses.

G. Behavior

1. Feeding. Reversing 12-hour light:dark intervals also reversed feeding and drinking behavior patterns of growing heifers. Sixty-five percent of the time at the feeder and waterers occurred during the light intervals irrespective of time of day. The extent of the effect varied with animals. The results suggest that light is a potential tool for controlling feeding behavior of cattle.

Preliminary observations suggest that time spent at the feeder daily decreases during estrus.

Feeding patterns of steers consuming all concentrate rations (90% corn) are similar to the feeding patterns of steers consuming roughage containing rations.

Contracted experiments at the Florida Agricultural Experiment Station on the formulation of supplements to control feed intake by beef cattle indicated that the use of salt is limited due to the variability among steers in their tolerance for salt. Animal fat and menhaden fish oil (10%) limited intake of the supplement and showed promise for future studies. (AH d2-40)

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AREA NO. 5: DAIRY CATTLE - BREEDING

Problem. Dairymen need information on improved genetic methods for increasing and changing productive performance and efficiency in order to reduce unit costs and to meet current and future market demands. Precise information is needed on the relative importance of performance traits, the heritability of certain traits, sources of variation, nature of inheritance, response to selection, and systems of mating. Research is needed on milk and blood constituents, specific and general combining ability, heterosis and adaptability in order to reveal new genetic traits of economic importance and to develop new genetic methods of bringing about livestock improvement.

USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by geneticists on basic and applied studies of the inheritance of the dairy cow, including experiments designed for evaluating the application of advanced genetic concepts to dairy cattle improvement. The work is in progress at Beltsville, Maryland, and cooperatively with experiment stations in 14 States and in laboratories in 17 foreign countries. Several of the studies contribute to the North Central and Southern regional dairy cattle breeding projects. Cooperation is also carried out with the National Association of Animal Breeders and with the various dairy cattle breed registry organizations.

The Federal scientific effort devoted to the research in this area totals 17.1 professional man-years. Of this number, 6.6 are devoted to genetics and interrelations of performance traits, and 10.5 to selection and systems of breeding.

A contract in the amount of \$20,000 per year is in effect with the Wisconsin Agricultural Experiment Station to study the meat production potential of dairy cattle. Its duration is four years, 1964-67.

A grant with the Agricultural Research Center, Tikkurila, Finland, provides for research on breed differences relating to antigenic properties of cattle blood, their inheritance relating to economic characteristics and genetic origin of the breeds. Its duration is for four years, 1961-65, and involves PL 480 funds with a \$61,804 equivalent in Finnish Finmarks.

A PL 480 grant with the Division of Investigaciones Agropecuarias, Ministry of Agriculture, Turipana, Colombia, for \$246,000 equivalent in Colombian pesos, supports work on the evaluation of the native breed, Costeno Con Cuernos, and Holsteins and Brown Swiss when selected for dairy traits under the hot and humid conditions of Northern Colombia, for the period 1962-67.

PROGRAM OF STATE EXPERIMENT STATIONS

Dairy cattle breeding research is conducted with State agricultural experiment station and college herds, institutional herds, and privately owned herds; with data available through the DHIA program; and in cooperation with artificial breeding associations in sire proving and similar studies. Areas of investigations include: (1) the estimation of genetic parameters such as heritability, genetic correlations, genetic transmitting ability, and heterosis, and (2) response to programs for genetic improvement. Specific items of study include selection response, milk constituents, crossbreeding, genetic abnormalities, climatic adaptability, blood antigens, milking rate, and efficiency of feed utilization. Much of the research is conducted under two regional projects--NC-2, Improvement of Dairy Cattle Through Breeding, and S-49, Genetic Methods of Improving Dairy Cattle for the South.

The USDA is cooperating on several research projects with the State agricultural experiment stations and participates actively in the two regional projects.

The total research effort on dairy cattle breeding research by the State agricultural experiment stations is 50.0 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Genetics and Interrelationships of Performance Traits

1. Relationships between internal and external anatomy and milk production of dairy cattle. Over a period of more than 30 years, cows of various breeds were slaughtered and measured for both external body form and internal anatomy. These studies were made to obtain information that might aid in the identification of potential superiority of performance in cows not having production records. Correlations for all relationships among 77 variables, including external body measurements, internal anatomical weights or measurements, and 6 measures of producing ability were computed on data from 184 Holstein and 195 Jersey cows. The highest correlations between external body measurements and production records included head length, length of withers to hips, length of shoulders to pin bones, height at withers, back and hips, and depth of forechest. No correlations were higher than 0.30. Body widths tended to be negatively associated with production records.

The highest correlations between internal anatomical weights or measurements and production records included those for weights of blood, heart, lungs, stomach, liver, kidneys, and length of intestines. These correlations were generally higher than those for external measurements. Production correlations with weights of thoracic and abdominal fat and carcass weight were distinctly negative. Correlations with weights of endocrine glands were low. (AH gl-2)

2. Relationships between internal and external anatomical characteristics. These studies were made to determine the relationships between certain characteristics in the external conformation of dairy cows, the dimensions of the thoracic cavity, and the relative sizes of various internal organs and glands that are essential to milk production. The highest correlations obtained for weights of heart, lungs, blood, and kidneys were with body length, height, head length, and body depth. The highest correlations involving weights of stomach, liver, spleen, and intestine length were with liveweight, body circumference, and body width. These external measurements had higher correlations with weights of thoracic and abdominal fat and carcass weight than with size of stomach, intestines, liver, or spleen. However, the correlations were nearly all of small magnitude and give little support to theories that one or a few external measurements are uniquely indicative of the size of an internal organ or anatomical structure. The usefulness of external measurements as an indicator of internal organ size is questionable. (AH gl-2)

3. Age effect on anatomical structures. A study of the effect of age at slaughter on external body measurements and internal anatomical weights and measurements was made on data from 350 Holstein and 346 Jersey cows at Beltsville and State experiment stations. Age at slaughter ranged from 4-10 years. Results from analysis of variance were not uniform but provide several general conclusions.

The greatest increases with age among external body measurements were for body depth, wedge in depth, body length, hip width, muzzle circumference, and head length. Body width, forehead width, pinbone width, heights at hips and pinbones, and shinbone circumference were least affected.

The greatest age effect on internal anatomical items were for stomach weight; intestine length; lung, blood, and kidney weights; and weights of pituitary, thyroid, adrenals, and thymus. Age had little effect on brain weight, carcass weight, and weights of thoracic and abdominal fat. (AH gl-2)

4. Genetic-environmental interactions in performance characteristics. In cooperation with the Tennessee Agricultural Experiment Station at Lewisburg, Tennessee, information has been accumulated on the importance of genetic-environmental interactions. A total of 101 Jersey cows on a ration of forage plus grain, and 104 on a ration of forage only have completed first lactations. These cows represent 13 different sire groups. The average M.E. FCM yield of the forage plus grain group was 12,483 pounds as compared to 10,192 pounds for the forage only group. The latter group produced 81.6% as much as the forage plus grain cows. Individual sire groups, however, ranged from 70.5% to 92.6%. The results indicated that sires generally showing superiority in one environment will also show superiority in other environments. There are exceptions however. For example, one sire whose semen was imported from New Zealand ranked 12th on grain plus forage but was 3rd on forage only. He was selected on the

basis of progeny test information in New Zealand which was obtained under conditions of forage only rations.

At Utah a similar experiment is in progress using Holstein cows. Production data for milk, fat, and FCM for 166 daughters of 13 sires have been accumulated. Production (2X-305-day ME) for sire groups on the all forage ration ranged from 7,595 to 10,868 of FCM, 1,056 to 1,403 pounds of total solids, and 291 to 365 pounds of protein. Daughters on the all forage ration produced 69.8%, 70.5%, and 69.3% as much FCM, total solids, and protein, respectively, as their contemporary half-sibs on the normal ration. Values ranged from 57% to 88% for individual sire groups. A statistical analysis showed a highly significant difference between sires and between rations for all measures of production. The sire by ration interaction was significant for the production of protein and total solids, but was non-significant for all other measures of production. The sire contributing most of the interaction was another bull whose semen was imported from New Zealand. Results to date indicate that progress could be made in selecting cattle that will perform better on one ration than another. However, this progress would at best be exceedingly slow.

Reproductive performance was studied with 128 daughters fed forage only or forage plus grain. Eight sire groups were involved. The average number of days from freshening to first heat was 51 for both rations and ranged from 33 to 68 for different sire groups. However, the forage only cows were bred and conceived earlier than the cows on forage plus grain. This occurred despite the fact that services/conception were the same for both rations. (AH gl-4)

5. Ration effects on production efficiency. Analysis of the research at Beltsville to determine the value of certain feeding regimes in estimating genetic differences among cows in feed efficiency is now completed. Mature Holstein cows were divided into two treatment groups. In treatment I, 23 cows were fed at an amount to support 14,000 pounds of FCM yield and 1500 pounds of body weight for the lactation period. In treatment II, 26 cows were fed individually at 110% of Morrison's maximum requirements for production and maintenance.

Although the results indicated that both groups utilized their feed at approximately the same relative efficiency, there was more variation among treatment II cows in all variables except feed efficiency. This was probably because some of the cows in treatment I were overfed and others were underfed relative to their requirements. Further evidence for this is the range in FCM yield in treatment I which was from 9,053 to 17,842 pounds.

The repeatability between successive lactations for FCM yield was 0.577 in treatment I and 0.565 in II. The corresponding values for feed efficiency were 0.354 and 0.404. There was a more similar consecutive lactation response between and within treatment groups in FCM than in feed

efficiency. (AH gl-4)

6. Meat production from beef, dual purpose, and dairy steers. This study was initiated in cooperation with the Beef Cattle Research Branch to determine the relative merits of various breeds of cattle and different management systems in the production of beef. Twenty-eight Holsteins, 23 Milking Shorthorns, 22 Jerseys, and 25 Herefords have completed the second replication of the study. The steers of each breed were divided into three feeding regimes from 180 days to slaughter. The rations were (a) all hay, (b) all hay until 5/6 of slaughter weight was attained and then a fattening ration, and (c) all fattening.

The average daily rate of gain from 180 days to slaughter for all steers fed either the high or low level of nutrition from birth to 180 days was 1.34, 1.51, and 1.65, respectively for the hay, hay-fattening and fattening rations. The Holsteins had the highest average daily rate of gain. They were followed by Milking Shorthorns, Herefords and Jerseys. The same trends were true for efficiency of gain.

The rib eye areas for Holsteins, Jerseys, Milking Shorthorns, and Herefords were 10.4, 9.34, 10.5, and 10.2, respectively. No significant trend due to ration appeared in any of the breeds except Herefords. In this breed, the steers fed a high plane of nutrition from 0-180 days had an average rib eye area of 9.0 as opposed to 11.4 for those fed the low plane, irrespective of the feeding regime after 180 days of age.

Tenderness studies, as evaluated by the Warner Bratzler shear, showed that Jerseys were the most tender, followed by Holsteins, Herefords, and Milking Shorthorns. For all the breeds except Jerseys, the steers fed the high plane of nutrition during the first 6 months and all concentrate from 6 months to slaughter were the most tender. However, Jersey steers fed the low plane of nutrition during the first 6 months and all concentrates from 6 months to slaughter were more tender than any of the steers in the other breeds. (AH d3-6)

7. Genetics of milk constituents. The β -lactoglobulin types of 812 individual cows of various breeds were determined. This work was done in cooperation with the Milk Properties Laboratory, Eastern Utilization Research and Development Division, Philadelphia. The results support the hypothesis that β -lactoglobulins A and B are controlled genetically by codominant autosomal alleles. There appear to be real differences between breeds in the frequencies of the alternative genes. The A and B genes occur in approximately equal numbers in the Holstein and Jersey breeds but all other breeds studied show a preponderance of the B gene.

Milk from five heterozygous cows were analyzed to estimate the relative quantities of β -A and β -B produced by these animals. The results indicate that β -A and β -B are produced in approximately equal amounts, with A being slightly in excess of B.

Lacteal secretions were obtained from two castrated males and typed for β -lactoglobulin. These animals were found to have β -lactoglobulins (B and AB) consistent with their expected genotypes as deduced from pedigree analysis. Lacteal secretions also were obtained from intact male calves at the age of 6 months and from sexually mature bulls. Some of these samples have been typed for genetically controlled casein and β -lactoglobulin variants and the results indicate that normal patterns are obtained. Thus, it appears that it will be feasible to type males directly for these genetic polymorphisms.

Preliminary studies indicate that the kind of αs_1 casein which occurs as a consequence of the mutant gene $\alpha s_1 - Cn^A$ can cause some physical differences in milk processing. It appears that milk containing A form of αs_1 casein forms a softer curd than milk containing the more common B form. Other differences are also suggested by the preliminary data and are being investigated.

Data on the genetics of the αs_1 and B-casein were pooled with data from workers in Philadelphia, Pennsylvania; Shinfield, England; and Edinburgh, Scotland. Data on 351 Jersey cows indicated that the two systems are not independent and suggested the hypothesis that the two loci are closely linked. The hypothesis was confirmed by family studies carried out independently in France. (AH gl-5)

8. Genetics of blood antigens and other biochemical polymorphisms in dairy cattle. The tenth biennial USDA Comparison Test in cattle blood typing in which 22 laboratories participated was held early in 1965. These laboratories were located in 17 countries. This program, by affording all the laboratories an opportunity to test a portion of each of 40 blood samples, gives an excellent means of comparing blood typing reagents. Determination of serum transferrin and hemoglobin types by electrophoresis was also done. The Beltsville laboratory participated in this latter part of the test and administered the program.

A method for concurrently typing for serum transferrin (Tf) and hemoglobin (Hb) genetic variants was developed at the Beltsville laboratory. A known amount of Hb from an animal is added to a sample of its serum and the mixture is electrophoresed in polyacrylamide gel. With this method, it is possible to determine the types for both of these systems from the stained gel.

Blood typing done by the Ohio State University Cattle Blood Typing Laboratory indicates that the β -lactoglobulin and blood group J loci are linked with 20% or more recombination. Distributions of transmitted gene pairs were as follows: J & A(3), J & B(19), - & A(20), and - & B(7). This distribution is significantly different from the expected distribution. The data failed to indicate that close linkage exists among any of the locus combinations studied. However, since the families studied were small, it is possible that more distant linkage exists but that it was not

detected because of approximately equal numbers of each linkage phase in the group of animals studied.

At Ohio, workers have investigated how each gene in the serum transferrin system provides for the occurrence of three different electrophoretic bands. No immunological difference was found between the different transferrins. Gel filtration and ultra-centrifuge studies of individual transferrins indicate that all of the transferrin forms are approximately the same size. Studies of the intensities of the different transferrin bands in disc gel electrophoresis indicate that the observed polymorphism may be a result of random association of two types of subunits to a genetic base in the molecule. Degree of iron-binding by the transferrin did not appear to be a factor in multiple band formation. (AH gl-6)

Five electrophoretically distinct iron-binding proteins were found in the blood serum of 350 cattle from the Louisiana State University and the Iberia Livestock Experiment Station herds. Three to five components were found in the individual cow sera samples. No significant relationship was found between these transferrin genotypes and breeding efficiency as measured by services per conception in Holstein cows. The transferrin type E was present in Brown Swiss-Jersey crosses but not in purebred Holsteins, Jerseys, Brown Swiss, or Holstein crosses. It was more frequent in the Sindhi crosses than the European crosses. Transferrin types DE and AE were present in the European crossbred cattle and the crosses with Red Sindhi breeding. There were no significant differences in the milk production of animals with different E genotypes in the LSU Holstein herd. Three electrophoretically distinct hemoglobins were found in the sera of cattle. Holsteins had only bovine hemoglobin A. As with transferrin E the frequency of hemoglobin B was greater in crossbred cattle carrying Sindhi breeding than in the European crosses. (AH g4-2)

9. Association with economic traits. The PL 480 project in Finland was completed in April 1965. Considerable difference was found in the frequency of various blood group genes between the Finnish and other Scandinavian breeds, especially in the B blood group system. No association was found between blood groups and the amount of white color in Ayrshire animals. Preliminary analysis of blood type and production information has been made using 81 blood typed Ayrshire bulls and their progeny tests for milk and fat production traits. The studies showed a significant relationship between the B blood group O_1A^1 and fat percent but did not confirm the previously reported association between $BO_1Y_2D^1$ and $BO_1Y_1D^1$ and fat percent. The significance of the O_1A^1 association is questioned since a large number of comparisons were made in the analyses and some would be expected to yield statistically significant results on the basis of chance alone. The Finnish workers conclude, on the basis of their preliminary studies, "that the relative importance of blood groups in predicting breeding value for production traits is probably low on the average." Thus, this study is essentially in agreement with others that have been reported. (E8-AH-1)

B. Selection and Systems of Breeding

1. Comparisons of inbreeding and outbreeding. Accumulation of data on crosses among 6 inbred lines of Holsteins and maintenance of controls has been continued. Results indicated that the increase in production with lactation number was not significantly different between inbreds and non-inbreds. However, most of the inbreds removed from the herd went out because of reproduction failure. This could be an indication that natural selection may eliminate the more homozygous types in older cows through reproductive unfitness. If so, it is possible that under practical conditions differential effects of mating systems regarding increases of production with age would be difficult to detect in any sample. General conclusions from the experiment are that: (a) inbreeding effects on economic traits were not predictable in stocks of different origin, (b) inbred individuals were lower in reproduction and productive merit than outbreds, (c) inbreds within lines were more variable than outbreds in their phenotypic expression of most economic traits, (d) the development and maintenance of inbred lines were costly, and (e) in most cases, the crossing of inbred lines did not produce individuals that were superior to outbred individuals. It appears that intense inbreeding without selection cannot be recommended for application by dairy cattle breeders. (AH g2-5)

2. The influence of parental relationship on the genetic merit of dairy cows and sires. This research was to determine the relative merits of linebreeding, outcrossing, and crossbreeding using progeny tested bulls of high merit as service sires. The actual first lactation FCM averages for the various groups were not significantly different. Results to date indicate that individual sire effects are more important than the effect of breeding systems.

Heifers from each mating system are being fed a standardized ration at the rate of 2.0 pounds per 100 pounds of body weight to determine if there are differences between animals and mating system in feed utilization for growth. The ration consisted of pellets containing 75% alfalfa hay and 25% concentrates. To date, a total of 18 outcrosses, 12 linebreds, and 17 crossbred heifers have finished 120-day feeding trials. The average daily rate of gain was 1.60, 1.50, and 1.62 for these groups, respectively. Corresponding values for efficiency of gain were .156, .152, and 1.54. (AH g2-24)

3. Sire and generation effects on genetic improvement. Data from the Beltsville proven sire project were studied to determine the rate of genetic progress. Each cow was compared to other contemporary cows belonging to the immediate preceding generation. The average increase for generations 1 through 8 as measured by 3X-365-day records was 546 pounds of milk and 20.7 pounds of butterfat. The largest increases occurred during the first four generations when production levels were lowest. The actual sire means showed significant differences among sires; however, when the means were expressed as deviations from herd mates, the

significance disappeared. Only 7 sires are included in the analysis.

Rate of genetic progress seemed to be much slower in generations 5 through 11 as measured by 2X-305-day records and was 21 pounds of milk and 12 pounds of butterfat per generation. Twenty-one sires were included in this phase and the differences between them were significant when studied on a deviation from herdmate basis and on an actual production basis.

The importance of using superior sires is demonstrated by comparing USDA AI Sire Summaries with sires used in the Beltsville herd. Most of the sires used since 1940 were chosen on the basis of their proof in one or a few herds. Since that time, however, 15 of the bulls have AI summaries on a large number of daughters in many herds. Comparisons of the AI summaries with the evaluations of the bulls in the Beltsville herd show that the USDA AI Sire evaluation is a good indicator of transmitting ability for production even within single herds. (AH g2-25)

4. Usefulness of heterosis resulting from interbreed matings.

(a) Effect of crossbreeding on growth, pregnancy, and production.

A study on the effects of pregnancy, lactation, production, and breed group on growth was made with data from the Illinois cooperative project. In the Holstein x Guernsey crosses, the Holstein inheritance stimulated growth more than the Guernseys. Breed of dam had a more significant effect on growth rate than breed of sire. Since no significant interaction of breed of sire and breed of dam was evident, the genetic effect on growth from 18-48 months is presumed to be largely a result of simple additive genetic action. Fleshing type measurements, such as heart girth and body weight, were more seriously affected from 24-36 months than skeletal measurements, such as body length, wither height, and chest depth. In the second generation (3/4 crosses) no significant effects were noted in the comparison of purebred versus crossbred cows. These results further support the conclusion that growth during 18-48 months is largely unaffected by heterosis from crossbreeding. (AH g2-23)

(b) Effect of crossbreeding on lactation persistency. First lactation records of 373 cows in the University of Illinois crossbreeding project were analyzed for effects of breed, mean milk yield, and month of calving on the within lactation variation for milk yield. The purebred Holsteins had the highest total within-lactation variance, followed by the four crossbred groups. The purebred Guernseys were the lowest. For each 1/16 increase in Holstein influence, there was an increase of 1.48 units in the total within-lactation variance. The linear regression of mean milk yield on successive 10-day periods changed -0.009 for each 1/16 increase in Holstein influence. The effect of month of freshening on the total within-lactation variance indicated a seasonal trend with freshenings from December through June being associated with high total variance and those from July through November with low total variance. A regression of mean milk yield per period on season was -0.73 for January through June and

-0.54 for July through September. Cows calving April-June showed a tendency for late lactation production to persist at a relatively constant level and hence have had the highest persistency. Cows freshening August-November ranked second and those calving December-March and July were lowest. There were no significant interactions of month of freshening and breed groups for any of the variables studied. (AH g2-23)

(c) The relative size and production of first and later calves. A study of the effects of parity on weight, heart girth, wither height, body length at 2, 3, and 4 years of age, on milk and fat production, and fat test showed that parity of birth of the cow had no significant effect on the productive performance or size of the animal. Although the parity constants were, in general, not significantly different from zero, those for second parity were consistently positive, and those for fourth or later parity were consistently negative. (AH g2-23)

(d) Body growth in purebreds and crossbreds. In the Illinois project, the effects of breed group, system of mating, and specific sires on six body measurements taken from 3-48 months of age were studied. Holsteins, Guernseys, and six intermediate crossbred groups were included. In two-breed crosses the breed of dam had a greater influence on body growth than breed of sire. Means for the two crossbred groups exceeded those of the purebreds at all ages and for all six variables. After 24 months of age, these differences were not statistically significant. The second generation (3/4 crosses) were generally intermediate to the two purebred groups but nearer the Holsteins at early ages. Results in the third generation (5/8 crosses) provided further supporting evidence that breed differences are largely additive genetic differences. There is evidence of a significant amount of heterosis for sires up to 24 months of age but not from 30-48 months. In each generation, the crossbred groups with Guernsey sires usually averaged near the population mean and those with Holstein sires averaged above the mean. (AH g2-23)

(e) The effect of crossing Holsteins and Guernseys on productive performance. Actual lactation yields of milk, fat, FCM, and fat test of 379 first calf heifers in the Illinois project were analyzed. Holsteins, Guernseys, and six groups of intermediate crosses were included. Breed of sire produced a larger effect than breed of dam on all four variables, but the interactions were not statistically significant. In generations 2 (3/4-breds) and 3 (5/8-breds) there were statistically significant linear trends from Guernseys through the crossbreds to Holsteins. Little evidence for non-additive genetic effects on lactation was found in these data. However, there was some indication of specific combining ability involving certain sire and female breed groups. All crossbred groups were above Guernseys but below Holsteins in all measures except for fat test. (AH g2-23)

(f) Performance of two-breed crosses among Ayrshire, Brown Swiss, and Holsteins. Preliminary results from the Beltsville project

indicate that average livability of female calves up to 3 months of age for the crossbred groups was the same as for the parental breeds. Losses of Brown Swiss purebreds and Brown Swiss crosses were significantly higher than for the other three groups up to 3 months, but the differences among breed groups were not significant for the percent born that completed one lactation.

The average daily gain in body weight from birth to 3 months of age was significantly higher for Holsteins (1.42 lb.) than for Ayrshires (1.19 lb.) and Brown Swiss (1.21 lb.). Daily gains for Holsteins during this period were also slightly higher than for the two-breed crosses. From 6 to 12 months of age the average daily gain for Ayrshires was significantly lower than for all other groups. These results indicate differences between the pure breeds in patterns of early growth which are largely eliminated by crossing. In general, Holsteins were significantly superior to Ayrshires, Brown Swiss, and Ayrshire-Swiss crosses but somewhat lower in production than the crossbred groups with 1/2 Holstein breeding. Preliminary results indicate that some crossbred combinations produce a little more efficiently than purebreds in first lactation.

There were no significant breed effects in number of days from calving to first heat, days from calving to first service, number of days from first service to conception, calving interval, days open during lactation, and proportion pregnant at 95 days after parturition, although two-breed crosses showed a slight superiority over purebreds. The proportion removed from the herd as non-breeders was nearly the same in all breed groups. (AH g2-23)

5. Genetic methods for developing adaptability. Of 489 terminal pregnancies in the LSU herd from 1959-64, 46.8% were females and 53.2% were males. In this period, 5.9% of the calves were born dead (stillbirths) with almost twice as many male calves being stillborn as females. Of the females born alive, 85, 82, and 74% remained in the herd up to 3 months of age, 17 months, and to first calving, respectively. Losses from 17 months to first calving were attributed primarily to nonbreeding causes. These findings indicate there is much opportunity for improvement in management and disease control.

Efficiency of reproductive performance of Jerseys, Holsteins, 1/2 Red Sindhi crosses, 1/2 Holstein crosses, 1/2 Brown Swiss crosses, and all crossbreds with Sindhi breeding, in the Iberia Livestock Experiment Station herd was studied. The measures used were days from parturition to first estrus; services per conception; days open in lactation; days from first service to conception; the proportion pregnant at 95, 120, and 145 days after calving with 1, 2, or 3 services; calving interval; and gestation length. All measures tended to rank the breed groups in the same order. Mean calving intervals among breed groups ranged from 381 to 409 days. Although the 1/2 Holstein and 1/2 Swiss crosses showed some superiority

in reproductive efficiency, as measured by calving interval, breed group differences were not significant. It does not appear that incorporation of the Red Sindhi enhanced reproductive efficiency under South Louisiana conditions.

Analyses of data from the State Prison herd at Reidsville, Georgia, showed no significant advantage of the crossbreds over Holsteins in rate of growth, productive performance, or reproductive efficiency, although the crossbreds did exceed the mean of the parents in most traits. The mean milk fat percent for crosses was approximately equal to the weighted mean for the parental breeds, but for the crosses milk, fat, and FCM yields were considerably greater. The milk and fat yield of the Jersey-Brown Swiss crosses surpassed the levels of the purebred Jerseys and Brown Swiss. Crosses with Holstein parentage approached the performance of purebred Holsteins in FCM, but were lower in total milk yield. The crosses required slightly fewer services for conception and the calving interval averaged 11 days less. (AH g4-2)

An analysis of production records on 521 Consteno Con Cuernos (a native breed) at the Turipana Station in Colombia showed wide variation in total milk yield and length of lactation. There were significant effects of age on total yield from first and second lactations, but not beyond. Seasonal effects were important for milk yield at all ages. System of milking was very important in relation to total yield. Cows with two lactations showed a significant increase in yield (+7.6%) from first to second lactation but increases in subsequent lactations were only 1%. The average lactation yields for cows calving November to April were 42.2% higher than for cows calving in the other 6 months. The low yields corresponded to the wet season rather than the dry season, a result contrary to the common view about feed supplies in the tropics. Cows milked with calf at foot averaged 1,542 pounds milk and 203 days in lactation, whereas, cows milked without calf averaged only 706 pounds milk and milked 106 days. It was apparent from these data that if the calf dies shortly after birth, the cow should be removed from the herd. There were also indications that the problem of milk let-down is a very serious one in these cattle. Results thus far do not indicate a high degree of dairy merit in this native breed. Preliminary studies of performance of purebred Holsteins in the same herd indicate that they are capable of much higher production levels than the native cattle. (S5-AH-1)

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AREA NO. 6: DAIRY CATTLE - PHYSIOLOGY

Problem. Fundamental physiological research is required as a basis for improving reproductive and lactational performance of cattle. Breeding failure is a major reason for the disposal of cattle, and results in great economic loss to farmers. Further information is required on the physiological action of hormones in controlling the reproductive process, correcting reproductive abnormalities, and stimulating lactation. Research is also required on physiological processes related to growth and development, nutritional and management requirements, and on heat tolerance of dairy cattle.

USDA AND COOPERATIVE PROGRAM

This is a continuing program, largely in basic research, conducted by physiologists and biochemists. The program is designed to elucidate the reproductive and lactational physiology of cattle, utilizing physiological and biochemical techniques, and to determine physiological mechanisms related to heat tolerance. The work is in progress at Beltsville, Maryland, and cooperatively at the Wisconsin, New York, Massachusetts, Texas, Louisiana, and Georgia Agricultural Experiment Stations. It is coordinated with the NE-41, W-49, and S-49 regional projects.

The Federal scientific effort devoted to the research in this area totals 8.7 professional man-years. Of this number, 3.9 are devoted to the physiology of reproduction, 2.0 to the physiology of milk secretion, 1.0 to the physiology of growth and development, and 1.8 to environmental physiology.

A PL 480 grant at Picassununga, Brazil, provides for research on the anatomical and physiological characteristics affecting heat production and loss of Zebu, European and Zebu-European crossbred cattle and the nature and method of controlling the inheritance. Its duration is five years, 1961-66, with funds of \$63,293 equivalent in Brazilian Cruzeiros. (Also in Area 5)

A project with the Veterinary Institute, Beit Dagan, Israel, in the Department of Reproduction, concerns work on a project entitled, "Comparative Studies of Repeat Breeders and Normal Cows and Heifers." It is for a five-year period and involves PL 480 funds to the extent of \$124,600 equivalent in Israeli pounds.

A PL 480 project with the Department of Applied Pharmacology, The Hebrew University, Rehovoth, Israel, on the mechanism of lactation and its augmentation by hypothalamic stimulation is in progress. It is supported for five years and is for \$126,767 equivalent in Israeli pounds.

A PL 480 project at Izatanagar, India, and one at Karnal, India, are in progress and relate to environmental physiology.

PROGRAM OF STATE EXPERIMENT STATIONS

Two regional projects NE-41, "Endocrine Factors Affecting Reproduction in the Bovine Female," and W-49, "Physiological Factors Affecting Fertility in Cattle" are concerned with this program. The work includes many basic studies on hormone methodology and interrelationships directed to determining mechanisms related to fertility so that losses from infertility may be reduced. Improvements in semen preservation continue to be sought.

Work also continues on the physiology of mammary gland growth and milk secretion with considerable emphasis on hormonal and other physiological influences. A portion of this work is also related to rumen function studies and intermediary metabolism of rumen metabolites as these affect both quantity and quality of milk. Physiological factors affecting mastitis are also being studied.

Other physiological work includes studies on milk fever, ketosis and other metabolic diseases, studies on genetic polymorphisms in blood and milk which may be related to production and work on the effects of environmental influences on physiological processes and production of dairy cattle. Animal behavior studies in relation to management and production problems of cattle are also in progress.

The research effort of the States on dairy cattle physiology totals 48.0 professional man-years. An additional 32.0 professional man-years are pertinent to Area 1 (Animal Biology) and are reported therein.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Physiology of Reproduction

1. Intrauterine inoculation with E. coli. The effects of repeated intrauterine inoculation with viable E. coli organisms upon the life span of induced corpora lutea and upon the uteri of 20 postparturient cows were studied. The possible modifying action of the suckling stimulus on these effects was also studied. Bacterial inoculation and the absence of suckling interacted to prolong the life of the corpus luteum. Animals in this treatment group did not return to estrus during a 27-day period. Inoculation increased corpus luteum weight and progesterone content.

E. coli inoculation increased the mean uterine weight at 41 days postpartum; the relative numbers of lymphocytes, plasma cells and polymorphonuclear leucocytes in the endometrium; the dilation and degeneration

of endometrial glands; and the amount of epithelial loss from the endometrium. Suckling decreased the mean uterine weight at 41 days postpartum, the degree of capillary congestion and gland degeneration in the endometrium, and the number of plasma cells present. Lymphocyte numbers were increased by suckling and by E. coli inoculation. (AH h5-6)

2. Progesterone administration during early part of estrous cycle.

The effect of exogenous progesterone on the estrous cycle length was studied in the cow, ewe, and gilt. Daily subcutaneous injections of progesterone in corn oil were begun on the first day of estrus. The number of animals, dose per day, and number of days injected were: 12 cows, 100 mg., 10 days; 12 ewes, 25 mg., 6 days; and 14 gilts, 200 mg., 10 days. The average control and treated cycle lengths were: cow, 20.7 and 16.7 days; ewe, 16.5 and 12.7 days; and gilt, 20.7 and 22.8 days. The treatment shortened the estrous cycle in the cow and ewe, but had no significant effect on cycle length in the gilt. (AH h5-6)

B. Physiology of Milk Secretion

1. Glycogen in normal and mastitic milk. The marked increase observed in the glycogen concentration of mastitic milk, as measured by the anthrone reaction, led to a detailed consideration of whether this anthrone positive material was actually glycogen or some other material which reacts non-specifically in the chemical determination. The behavior of several milk proteins, nucleic acids, and carbohydrates was studied when carried through the same milk glycogen procedure. Casein and lactalbumin gave a slight reaction with the anthrone reagent but β -lactoglobulin, bovine serum albumen, DNA, RNA, and lactose were negative. Use of a hydrolysis procedure and an enzymatic determination for glucose demonstrated that the compound present in normal and mastitic milk was actually glycogen. The protein, pH, lactose, chloride, and histamine content of mastitic milk was also studied. Large increases were observed in chloride and histamine, and a fairly large decrease in lactose. (AH g3-8)

2. The mechanism of lactation and its augmentation by hypothalamic stimulation. The interrelationship of the hypothalamus and the anterior pituitary gland in stimulating lactation was studied in Israel by depressing the activity of the hypothalamus with tranquilizers and other drugs. Forty-six phenothiazine derivatives were studied in an attempt to stimulate lactation without undue general depressant effects. Perphenazine sulfoxide was found to be especially effective in promoting lactation without tranquilizing. Stereotactic studies were undertaken to localize the site of a prolactin-inhibiting factor. Stereotoxic introduction of canules with the lactogenic phenothiazine derivatives into the hypothalamus of rabbits produced copious lactation. These experiments

demonstrated that the prolactin-inhibiting factor was located in the posterior basal region of the hypothalamus, and that perphenazine, by eliminating the hypothalamic prolactin-inhibiting factor, can initiate release of prolactin and cause lactation. (A10-AH-3)

3. Lactose content of the mammary gland. Lactose changes were studied at 5-day intervals during pregnancy, parturition, and lactation in primiparous rats. A method was developed for the separation of lactose from mono- and poly-saccharides by charcoal-celite chromatography, and applied to milk and mammary gland samples. Contrary to previous reports in the literature, little or no lactose was detected in the pregnant non-lactating gland. As growth of the mammary gland proceeded there was a steady decline in the lipid of the gland, from 65% for the non-pregnant gland to 30% at parturition. Milk lactose increased from 1.2 to 2.2 g/100 ml during 20 days of lactation. (AH g3-8)

C. Environmental Physiology

1. Effects of heat stress on the blood proteins. Two experiments were conducted at Louisiana State University to determine the effect of heat stress on total blood serum protein concentration, electrophoretic components of the serum proteins, changes in hematological attributes, and growth responses of Holstein heifers. Eight hours of exposure to a temperature of 95°F. resulted in no significant changes in blood constituents compared to exposure to 65°F. Heifers were exposed to a period of constant 65°F. temperature, followed by a period of cyclic hot conditions (75, 85, and 95°F.), and a third period of constant 65°F. Blood hematocrit values were significantly lower during the hot period than in the two cool periods while total serum proteins were significantly higher. Albumin, alpha-globulin, beta-globulin, and gamma-globulin showed no marked change. Thus, it appears that there is no disturbance or alteration in the biochemical mechanism of synthesis or catabolism of blood serum protein fractions under heat stress. Daily body weight gains were lowered during the cyclic hot period. (AH g4-1)

2. Rates of moisture evaporation from the surface of cattle. At Texas A&M University sweating rates were obtained on 3 age groups by measuring moisture loss and salt accumulation on the skin. Estimates average evaporation rates for Holsteins were significantly higher than for Jerseys, and Jersey-Brahma crosses. Rates for first lactation animals were somewhat higher than for yearling heifers and mature cows. As the average daily ambient temperature rose from 73-83°F., evaporation rates for Holsteins, Jerseys, and the crosses increased 6.8, 1.2, and 1.0%, respectively. Average skin temperatures for the three breed groups were 100.6, 99.6, and 99.0°F. Skin temperatures were more closely associated ($r = +0.99$) with evaporation rates than respiration and pulse rates or rectal temperature. Salts accumulated on the skin of the Holsteins was significantly higher than for

the Jerseys or crosses. The relation of salt accumulation on the skin to sweating rate suggests that changes in salt concentration on the surface may be used in estimating the sweating-rates of cattle. (AH g4-1)

3. Use of tympanic membrane temperature for determining response to heat stress. Since temperature near the tympanic membrane of the inner ear has proven more accurate than rectal temperature for assessing man's response to heat stress, this method of measurement and its relation to rectal temperature in cattle was explored. Tympanic and rectal temperatures recorded at 2-minute intervals on 10 cows during 6 hours of changing air temperatures were used for comparisons. Tympanic temperature was much less variable and significantly lower at all air temperatures than rectal temperature. An increase in chamber temperature was sensed at the tympanic membrane within 2-4 minutes, whereas a rise in rectal temperature was not evident in most animals for about 20 minutes. Rectal temperature also lagged behind when chamber temperature was lowered. Differences among cows, methods, and periods were important as well as cow-by-period and method-by-period interactions. Fistulated cows, with most of the rumen contents removed, were exposed to heat stress until 1°C. rise in body temperature was obtained. While room conditions were continued at 42°C., five kg. of ice were placed in the rumen. Again tympanic temperature responded by a marked decline within 2-4 minutes but a decline in rectal temperature was not evident for approximately 20 minutes. Hypothermic studies indicate that speed of response is more important than absolute temperature in identifying the mechanisms which are brought into play as counter measures. These studies show that temperature changes brought about by either external or internal stimuli can be identified more rapidly near the tympanic membrane than by rectal measurements. (AH g4-1)

4. Effect of dietary fats and heat stress on the fatty acid composition of milk. Twelve Holstein cows were used to test the effect on 9 milk fat acids when 10% saturated or unsaturated (crude soybean oil) fat is added to the concentrate ration under cool (50-60°F.) and high (90°F.) temperatures. Under cool conditions the high fat rations depressed the proportions of C₁₂ through C₁₆ milk fat acids. Palmeric and palmitoleic acid levels were depressed most by the unsaturated oil. Stearic, oleic, and linoleic acids were increased by both high fat rations. The unsaturated oil was most influential. The 90° temperature depressed the levels of lauric, myristic, tetradecenoic, pentadeonoic, palmitoleic, and linoleic acids but increased the levels of saturated palmitic and stearic acids. In these tests ration effects were more important than temperature effects on the proportion of milk fat acids, but the reverse was true for total milk fat secretion. Among-cow variance was not significant for changes in milk fat acids, indicating that all cows responded similarly. (AH g4-1)

5. The effect of thymectomy on growth and antibody production of calves. Six Holstein male calves were thymectomized 24-48 hours after birth and 6 pairmates had sham operations for studies of the role of the thymus gland in early immunological defense mechanism development. There were no discernible differences between pairmates in blood cell

counts and hematocrits, made at weekly intervals. At 3 months of age, all calves were challenged with whole sheep blood at weekly intervals for 4 weeks. The antibody titers for the thymectomized calves were approximately 64% of the level in the pairmates the first week following the initial injection of sheep cells. However, after the fourth challenge there was little difference in the antibody titers of the two groups. This indicates that thymectomy impaired but did not destroy antibody production. The thymectomized group also had a greater incidence of scours in the first 3 months and lower rates of gain from 30-120 days. Thus, it appears that the thymus gland is important in postnatal development. A technique for removal of both the thoracic and cervical portions of the thymus gland was developed as a part of the study. The more difficult thoracic portion was removed (97% of the total thymus) through the second intercostal space while the calf was lying on its right side. (AH g4-1)

6. Clipping the hair coat to improve heat tolerance. Heifers with the hair coat clipped to less than 1/4 inch were compared to normal coated pairmates under summer conditions and under very high temperatures in a psychrometric laboratory at Pirassununga, Brazil. Clipping did not have a significant effect on body temperature, respiration rate, pulse rate, number of red blood cells, hemaglobin, or hematocrit. Also, clipping did not change the ranking of the breed groups in their response to heat stress. The thickness of the initial coat covering on the animals was 1/2 inch or less with only a small amount of hair being removed. These tests, which were made under humidity conditions of less than 60%, indicate that clipping "short-coated" animals does not improve their comfort under low humidity conditions. (S3-AH-7)

7. Studies of heat tolerance of Indian cattle and buffaloes. Heifers representing 5 breeds of native cattle (Hariana, Sahiwal, Tharparkar, Gir, and Kankrej) have been subjected to various regimes of controlled temperature and humidity at the Indian Veterinary Research Institute, Izatanagar, India. The measures used to evaluate the responses were body and skin temperatures, respiratory rate and volume, pulse rate, and rate of sweat secretion. Within breed group variance was found more important than among group variance for all measurements under cool, hot-dry, or hot-humid conditions. These findings are contrary to the general opinion that the breed differences are obvious. (A7-AH-1)

8. The use of high forage rations for growing calves and lactating Indian-type cows. Studies with Tharparkar, Sahiwal, and Red Sindhi heifers between 7 and 12 months of age showed that during this age span 50% of the concentrate mixture could be replaced with forages without impairing growth. This type of feeding reduced the cost of rearing the calves nearly 50%. The hemaglobin, calcium, and phosphorous values remained normal on the high roughage diets. There were no differences among breeds in response to the feeding systems nor was there a significant interaction between breed, season, and systems of breeding. Preliminary observations with lactating cows also indicate that Indian breeds can

maintain expected milk yields when the protein requirement is supplied solely by home-grown fodder. (A7-AH-6)

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AREA NO. 7: DAIRY CATTLE - NUTRITION AND MANAGEMENT

Problem. Information on the nutritional processes and requirements of dairy cattle is needed to obtain a more precise evaluation and a better understanding of feeds and rations as a basis for improving feeding practices on farms. Shifts in sources of nutrients fed to dairy cattle require studies on the optimum combination and specific supplements needed in order to provide for the most profitable income over feed cost. Dairymen need to reduce the total cost of feed and labor. They need to improve husbandry and farm management practices through more efficient use of equipment, bedding, feeding and milking systems.

USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by biochemists, nutritionists, and dairy husbandmen and is aimed at increasing basic and applied knowledge in the feeding and managing of dairy cattle. Considerable emphasis is placed on basic research. Specific studies at Beltsville, Maryland, concern the relationship between net energy, metabolizable energy and total digestible nutrient values; the relationship between digestible and chemical composition and solubility of feed constituents; calorimetric techniques; composition of forages at various stages of harvesting and storage; and factors influencing the chemical quality, palatability and feeding value of silages.

Cooperative projects at State experiment stations concern variations in efficiency of forage utilization by dairy heifers at Utah, effectiveness of various ensiling procedures at Tennessee, and influence of management and environmental factors on adaptability of cattle to the Southeast at Georgia (cooperative with Agricultural Engineering).

Scientists at Beltsville are engaged in studies on the environmental conditions and the mechanisms of infection involved in bovine mastitis. In cooperation with Agricultural Engineering, Entomology, and Eastern Utilization, research is in progress on electrically-controlled and operated equipment for reduction of labor in dairy cattle management; on the evaluation and development of physical methods for the control of flies and other dairy cattle pests; and on the relationship between management practices and milk quality, including flavors.

A grant with the Government Agricultural College and Research Institute, Ludhiana, which is affiliated with Punjab University, Chandigarh, Punjab, India, provides for research on factors affecting the utilization of low-grade roughages and production of volatile fatty acids in the rumen of cattle. Its duration is for five years, 1962-67, and involves PL 480 funds with a grant of \$86,598 equivalent in rupees. (Pertains to Area 1 also)

A contract in the amount of \$10,000 per year to evaluate the feeding value of newer corn hybrids is in effect at the Maryland Agricultural Experiment Station. Duration four years.

A contract in the amount of \$25,000 per year to study the effects of level of concentrate feeding on cost of milk production is in effect at Cornell University. Duration four years.

The Federal scientific effort devoted to research in this area totals 28.3 professional man-years. Of these, 8.5 are in digestion and metabolism, 7.4 in forage evaluation and utilization, 3.1 in nutritional requirements, 3.6 in calf feeding, and 5.7 in management practices, equipment, and facilities.

PROGRAM OF STATE EXPERIMENT STATIONS

Calves. At what age and why do calves stop absorbing antibodies from the colostrum is still a moot question. Efforts are being made to reduce the milk feeding period. Different levels and kinds of vegetable oils along with emulsifiers, are being tried, especially for veal production. The newer antibiotics as well as digesters (enzyme preparations) are being studied. Others are interested in the synthesis of the B-vitamins in the intestine, in dextran as a source of iron, and still others in the zinc and manganese requirements of young calves.

Pregnancy and lactation. Much more emphasis is now being placed on the condition of the cow at time of freshening including the permeability of the placental membrane to nutrients circulating in the maternal blood stream. Almost every station is still testing the effects of high quality forage on milk production, or in vitro with an artificial rumen. The validity of the Morrison feeding standards are being questioned for high-producing cows. As a result many experimental animals are being challenged with liberal grain feeding immediately on freshening. The effects on the composition of the milk of high grain feeding, including processing of the grain, are also under investigation. Efforts have also been made to increase the fat in the ration, especially unsaturated fats, in the hope of not only producing milk more economically but with more polyunsaturated fats present. High fat rations might also be less heating.

Copper compounds have been injected intravenously to see if they influence the susceptibility of cow's milk to becoming oxidized. Fluorine has been fed at various levels over long periods of time. There is also the problem of nitrogen fertilization on the availability of magnesium in forage, and of nitrates in the plant on the vitamin A reserves after feeding, including their effect on reproduction. What is the volatile compound in ladino clover that sometimes imparts an undesirable flavor to milk? Can these suspected compounds be tagged with a radioactive compound and thereby be traced and identified more readily? Will drugs like tapazole, thyroxine, diiodosalicylic acid, nitrofurazone and many others

benefit the lactating cow?

The total research effort on dairy nutrition and management at State stations is 136.0 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Digestion and Metabolism

1. Summarization of all available literature data on energy balance trials with lactating cows. The data from all laboratories throughout the world having conducted energy balance trials with lactating dairy cows (1905-65) were summarized, using a computer program developed for this purpose. This was necessary so as to obtain a common basis for comparing these experimental results. In the past different factors were used by many laboratories, and various "corrections" made interpretation difficult. Units used to express results and reports published in foreign languages also made direct comparisons difficult. These reports showed that almost no studies had been conducted with high-producing cows. They also illustrated that very few experiments had been performed with cows using body fat as the source of energy, a common occurrence during early lactation with high-producing dairy cows. Regression analyses showed that the overall efficiency of utilization of metabolizable energy by lactating cows was 57-67%, depending on whether ME consumed/kg^{3/4} or energy balance /kg^{3/4} was employed as the independent variable. The maintenance requirements estimated in this manner would be 121.6 kcal ME/kg^{3/4}/24 hr. or 56.4 kcal net energy/kg^{3/4}/24 hr. (AH h2-8)

2. Results of energy balance trials with lactating cows. At Beltsville, the results of the first series of energy balance trials with lactating dairy cows have been analyzed. The original overall conclusion based on the first 4 trials was confirmed; namely, that ration composition did significantly affect the efficiency of utilization of dietary energy. The absolute values were dependent upon the assumptions used for estimating maintenance requirements and corrections for tissue losses and gains.

Data were analyzed involving rations A (64% alfalfa and 36% concentrates), B (84% alfalfa and 16% concentrate mixture of corn-soybean meal) and C (100% alfalfa). Ration A exceeded B, and B exceeded C in regard to (a) efficiency of utilization of metabolizable energy (ME) for milk production, (b) digestible energy (DE), (c) digestible dry matter, (d) digestible nitrogen, (e) digestible carbon, (f) digestible organic matter, (g) TDN on a dry matter basis, (h) metabolizable energy content, and (i) total rumen concentration of volatile fatty acids. Opposite trends for rations were found for (a) maintenance requirements, (b) metabolizable energy consumed, and (c) rumen pH. Estimated net energy intake and total energy balance values (including milk production plus tissue deposition) were lowest for C but of similar magnitude in A and B. Ration effects were significant for efficiency of utilization of metabolizable energy for

milk yield, maintenance requirements, concentration of propionic n-butyric, iso-valeric and n-valeric acids, and percent of nitrogen intake lost in feces and urine. Non-significant differences due to rations were found for blood ketones, percent milk fat, solids-not-fat, milk protein, total milk produced, body temperature, and percent nitrogen stored in milk and tissue.

These results demonstrate the importance of differences between rations as they affect the efficiency with which TDN, ME, and/or DE are utilized by cows. Factors derived from these data for rations A, B, and C were 2133, 2118, and 2129 for DE/pound TDN and 1746, 1743, and 1753 for ME/pound TDN, respectively. The ME/DE ratio was found to be dependent upon the amount of feed consumed; thus, the commonly used average factor (ME=82% of DE) can be incorrect when applied to rations that are being fed above 2 times maintenance. Derived factors for 5 times maintenance (approximately full feed for a lactating dairy cow) were 86.6, 87.9 and 87.1 for rations A, B and C, respectively.

Results to date show that the methods and equations being developed will enable determining net energy values of feeds and rations directly from current tables of feed composition and with greater accuracy than previously possible. They also indicate that TDN or other average factors now in use are in error and underestimate the feed actually utilized by the animal.

It has been noted that as animals consume greater quantities of feed, the digestibility of the ration decreases. This was noted in these studies, but the degree of depression was not nearly as marked as that found by other workers. It was also found that the depression in digestibility of the rations used in these studies was compensated for by decreased losses in the urine and methane. (AH h2-8)

3. Development of chemical methods for determining the nutritive value of feeds and forage.

(a) Cell-wall constituents. A procedure was developed last year which was satisfactory for forages, but not for corn silage or concentrate feedstuffs because of an interference of starch with the neutral detergent reagent. It has been discovered that starch may be easily removed by boiling the sample with 1% salicylic acid, and then with the neutral detergent reagent. This modification remains to be standardized. Such a method with applicability to all feedstuffs would be of considerable importance to feed manufacturers and to those concerned with livestock feeding, including non-ruminants. (AH h2-6)

(b) Sample preparation. Because of the problem of inducing artifacts by oven drying of forage samples, an alternate procedure has been developed for silages and fresh forage, whereby 2 kg. of the forage are frozen and passed through a meat grinder with a 0.25 inch plate. The

resulting mass is mixed in a large plastic bag and sub-sampled. It has been found that samples as small as 2 g. of wet matter are representative of the parent material. This mode of sample preparation is being used in conjunction with the determination of lignin, acid-detergent fiber, cell-wall constituents, total sugar, crude protein, and dry matter determinations.

(c) Studies on the manner in which lignin affects digestibility. Previously, it had been shown that lignin affected the nutritive availability of the cell wall fraction only, and that soluble components and protein are not influenced by lignification. Further analyses and statistical studies show that within the cell-wall fraction, hemicellulose and cellulose fractions have similar digestibilities and that both are highly correlated with the lignin content of acid-detergent fiber. (AH h2-6)

(d) Development of prediction equations for digestibility. A regression equation was developed on the basis of the concept of an availability index. Two factors were recognized in this equation; the quantity of soluble cell contents, and the degree of lignification. A second prediction equation was developed on the principle of summation, in which the completely digestible cell contents are added to an estimated digestible amount of cell walls. From the sum (equal to true digestibility), an estimate of the endogenous excretion of dry matter is subtracted to give apparent digestibility. While this second prediction equation is more involved, it seems to have greater precision in predicting the nutritive value of some kinds of forages. (AH h2-6)

4. Chemicals in milk.

(a) Dimethoate toxicity. The feeding of corn silage treated with a technical grade of dimethoate showed some evidence of toxicity in an earlier trial at Tifton, Georgia. Therefore, a second experiment was conducted using a pure form of dimethoate applied to the corn crop at the rates of 16 and 32 oz. per acre. It appears that dimethoate persists in the silage since about 40% of that present at the time of ensiling was present after 80 days of storage. The intake of silage by the lactating cows was not affected by the residues in the silage. No dimethoate residues were found in the milk, with the limit of detection at about .002 ppm. Blood cholinesterase inhibition was not detected. It was concluded that treatment of corn with as much as 32 oz. per acre will pose no residue toxicity problems with lactating dairy cows. (AH h2-14)

(b) Preparation of milk fat for Heptachlor analysis. The usual method for the separation of fat from milk for insecticide analysis is to separate out the cream with a cream separator, followed by treatment with sodium sulfate and extraction with hexane. The Stanley and Fauvur method was adapted to separate out the milk fat for the analysis. Analysis of samples of milk using both methods of separation gave similar heptachlor epoxide values. The adapted procedure required about one-fourth the time previously required to prepare the fat for analysis. (AH h2-14)

(c) Endosulfan (Thiodan). In studies conducted at Tifton, Georgia, endosulfan was applied to Bermuda grass at the rate of 4, 8, and 16 oz. per acre. After 7 days, the forage was harvested as silage and 100 pounds of corn were added per ton of chopped grass. After a 78-day storage period, the silage contained 0.41, 0.70, and 2.35 ppm. of endosulfan which was 40, 30, and 44% of that in the original silage. The 3 silages along with control silage were fed to 16 lactating cows for a period of 21 days. Milk produced by cows consuming daily adjusted averages of 15.6, 16.6, 16.4, and 17.2 pounds of silage dry matter for the control, 4, 8, and 16 oz. treatments, respectively, was free from detectable endosulfan. A compound found to be endosulfan sulfate was found in the silage. However, none of this compound was detected in the butterfat. (AH h2-14)

B. Forage Evaluation and Utilization

1. Dry matter losses in bunker and gas tight silos under adverse conditions. Low-moisture orchardgrass was used to obtain a direct comparison of bunker and Harvestore storage with regard to preservation and feeding value. Poor drying weather caused filling to extend over an 8-day period, hence, rather extreme exposure of bunker stored forage occurred before final sealing. Additional exposure was caused by cattle damaging the top seal. Recovery of dry matter for feed was about 72% in the bunker and 84% in the Harvestore. However, there were no appreciable differences in the feeding value of recovered silage. It was concluded that delays likely encountered when storing low moisture grass are particularly detrimental to preservation efficiency of a bunker. However, the effect on feeding value may be rather small. (AH h3-3)

2. Acceptability of low-moisture silage by cattle. The acceptability of low-moisture alfalfa silage from conventional silos, as measured by voluntary intake, was positively correlated with dry matter content over the range of 30-70%. However, intake of dry matter content above 50% usually was not increased. Fermentation was progressively more restricted as forage dry matter content increased, but dry matter digestibility was not significantly affected. Efficient preservation may be achieved at average dry matter contents up to 63%, with occasional unexplained exceptions.

These experiments indicate little reason to strive for dry matter contents above 50%. However, higher contents, which may be encountered unintentionally under practical conditions, can be accommodated without serious disadvantages. (AH h3-3)

3. Summer feeding of low-moisture orchardgrass silage. In this experiment, 52% dry matter orchardgrass was stored in a 10' x 35' concrete silo. Feeding commenced May 16, the day after filling was complete. Silage removed during the first 2 weeks showed a marked tendency to heat, was of poor chemical quality, contained about 10% spoilage, and was rather unpalatable to dairy cows. Following this initial period, quality and

consumption levels were good and little spoilage was found. It appears that summer feeding of conventionally stored low-moisture silage is quite feasible if a 2-week period between filling and feeding is allowed. (AH h3-3)

4. Effect of Tylosin and zinc bacitracin on silage quality. Previous investigations of the effects of the antibiotics Tylosin and zinc bacitracin on improving silage quality were inconclusive, partly because of good quality control while making the silage. The effects of these materials under more adverse conditions were tested by applying them to high nitrogen orchardgrass stored in 4' x 8' silos. Periodic bored samples over a 68-day period indicated no consistent effect on quality. A final sample, taken at 145 days of age, showed that the pH and ammoniacal nitrogen values for control silage were distinctly higher than for either treatment. Of even greater interest was the marked deterioration in quality of all silages between the 68- and 145-day boring. It is rather common practice to choose an arbitrary age such as 30 or 60 days on which to evaluate silage treatments. The implication being that silage quality is stable after this age. These data show that both absolute and relative quality changed markedly after 68 days of age. These findings raise the question of when if ever does a silage become stable in quality and at what age should evaluations be made. (AH h3-3)

5. Estimation of harvesting losses. Lack of precision in determining harvesting loss is associated with error in estimating the amount of original crop, rather than measurements of the amount actually harvested. In cooperation with Forage and Range Crops Research Division, it was found that dry matter of the standing crop per acre could be estimated with standard errors of about 100 to 200 pounds, which amounted to about 3-6% of the mean yield. Between 19 and 40 small strips per two-acre plot were required to obtain this precision. Estimates of the area harvested were made by ground measurements (Coop. A.E.R.D.) and by aerial photography (coop. Forest Insect Laboratory). Differences of about 4.5% were found between methods of measurement. It was concluded that this orthodox approach to harvesting loss measurements would be useful for distinguishing differences of about 20%, but it would be very laborious.

A second approach eliminated the need for strip samples by substituting the total yield of a direct-cut treatment. The problem of area measurement was reduced to the measurement of the linear distance harvested and making certain that the full-cut width of each machine was utilized. Losses of 1.0 and 2.6% were measured in two replications of field-cured baled hay by this method. These small losses may be associated with elimination of raking by use of a windrower. Slow drying (up to 6 days) had a negligible effect on dry matter loss, when done on portable trays with little chance for mechanical loss. (AH h3-3)

6. Effect of drying on silage intake. Previous data have shown that the dry matter of good quality wilted grass silage was not consumed in

as large an amount as the same crop made into hay. When the wilted silage was dried, intake was not improved. New data, however, show that low quality high moisture orchardgrass silage with a high pH was consumed in greater amounts when dried, or dried and then soaked in water. This suggests that intake of poor quality grass silage is improved by drying and that a study of the portion lost in drying, by volatilization of some of the silage constituents at a high pH, might clarify the cause of poor silage intake. It is also apparent that water, per se, in the silage is not the direct factor involved in intake. (AH h3-3)

7. Inhibition of aerobic spoilage in low-moisture silage. Eleven fungicides which are used for other agricultural purposes were screened by observing their ability to control mold growth in finely chopped hay reconstituted to about 50% moisture. The test was conducted in unsealed one-quart jars. The fungicides were added at 500 ppm. All but one failed to control mold growth over a 12-day period. The one effective material was 3,5-dimethyltetrahydro-1, 3, 5, 2H, thiodiazine-2-thione which is used as a soil fumigant sold under the trade name Mylone. Treatment with as little as 125 ppm. was found to prevent visible mold for 20 days in 50% moisture silage stored in unsealed jars.

A wheat bran mixture containing 25% Mylone was used to treat a low-moisture alfalfa stack. A control stack was also used. The efficiency of the treated stack was markedly improved as indicated by a lower percentage of spoilage and greater percentage of good silage. The amount of dry matter lost (gaseous loss) was surprisingly small in both stacks in view of the extensive spoilage. Chemical analyses of the unspoiled silages showed no differences in composition that could be related to treatment. Limited observations showed that similar amounts of silage dry matter were consumed from treated and control silages.

Although not conclusive, it appears that Mylone could be very effective in reducing certain types of spoilage and that the palatability of silage would not be reduced by this treatment. Possible problems of toxicity and milk residues have not been investigated. (AH h3-3)

8. Biochemical studies relating to silage investigations. The chemical quality of ensiled annual forages was studied in 7 sorghums and one each of sudan and millet. Three or four stages of cutting were used. Forages were ensiled in quart jars and assayed after 90 days for pH and ammoniacal nitrogen. The chemical measures of quality were related to the initial sugar, protein, dry matter, buffering capacity, and osmotic pressure of the forages. Covariance analyses showed the sugar-protein interaction to be important in determining pH and ammoniacal nitrogen. It also showed that chemical quality can be predicted by regressions based on sugar, protein, and dry matter.

In crops where difficulty was encountered in producing a good quality silage, the soft dough stage of seed development appeared to be the best

stage for ensiling. (AH h3-1)

C. Feeding Heifers

1. Factors affecting the intake of hay-crop silage by dairy heifers. When fed as the sole ration to growing dairy heifers, the dry matter intake of direct-cut hay-crop silage is nearly always lower than the intake of the same forage preserved as hay. The present experiments were conducted to accumulate more data on the composition of direct-cut silage and hay, and their respective digestibility and nitrogen retention when fed to dairy heifers.

The direct-cut silage contained less cell-wall material and thus required less space in the ruminant gastrointestinal tract than the corresponding hay. The lignification of the fiber was similar in both forages. Thus, unless the rate of digestion were reduced for silage, relative to hay, an accumulation of insoluble fiber in the rumen would be unlikely.

The energy digestibility was equal for the silage and hay. While the silage-fed and hay-fed animals digested about the same percentage of nitrogen, the silage-fed animals gained less weight and retained more nitrogen per unit of weight gain. These results indicate that the lowered growth of the silage-fed animals was not due to inadequate nitrogen retention but rather to inadequate energy intake. The inadequate energy intake appears to be associated with palatability or taste preference rather than the accumulation of feed residues in the rumen, which is commonly thought to limit hay intake. (AH h1-1)

2. Particle size fractionation of cell-wall constituents. A method has been developed whereby the neutral detergent fiber portion of forages is separated into various particle size fractions by dry sieve analysis. The method consists of the isolation of cell walls by treatment of the sample with neutral detergent reagent followed by acetone and hexane washings. Sufficient sample was used to yield approximately 10 grams of cell walls. Preliminary studies have been made on particle size with feces, rumen contents, and ground forages. Particle size diminution, resulting from pelleting in addition to that of preliminary grinding, has been demonstrated using this method. The values for modulus of fineness of fecal cell walls were greater for animals fed alfalfa hay than for animals fed alfalfa silage. They were also greater for animals fed alfalfa than for those fed timothy. There was no significant effect due to level of intake. However, based on a limited number of observations, it appears that at high levels of intake (3X maintenance) greater proportions of larger particles would be excreted. (AH h1-1)

3. Effect of nitrate on utilization of corn silage carotene. Twelve Holstein bull calves from 91 to 155 days of age, depleted of their vitamin A reserves, were fed a concentrate mixture low in carotene ad libitum and 454 g. skimmed milk powder per day mixed with water. The calves were fed

nitrate (KNO_3) at levels of 0, 147, and 440 mg./kg. body weight and carotene (from corn silage) at levels of 44, 53, 70, and 97 $\mu\text{g}/\text{kg}$. body weight. Concentration of blood serum carotene, serum vitamin A, and cerebrospinal fluid (CSF) pressures were determined biweekly during the 123-day experiment. The effect of dietary carotene levels on these three variables was linear and significant. There were no significant differences in these variables due to level of nitrate. There were no significant differences among rations for average daily gain and concentrate intake. It was concluded that the added nitrate had no effect on the utilization of corn silage carotene by Holstein calves. Carotene from corn silage was generally as effective as dehydrated alfalfa leaf meal in preventing increased CSF pressure in calves. (AH h1-5)

D. Management Practices, Equipment and Facilities

1. Bovine mastitis - cell counts as estimators. Comparisons were made on 1,214 milk samples between direct counting of body cells (leucocytes) and the California Mastitis Test (CMT), which is an indirect method of estimating leucocytosis. Microscopic investigations showed that 22.3% of the samples that gave a CMT reading of 0 contained leucocytes in excess of 21,000 per ml. Milk samples that scored 1, 2, and 3 on the CMT, misclassified 71.6%, 51.8%, and 4.7%, respectively, when compared to direct microscopic counts. These results indicate that the CMT is reliable only as an estimator of leucocytes when the level of leucocytes is in excess of 1,000,000 per ml.

Four successive milk samples were drawn from 2 groups of cows prior to milking. Cell counts and CMT's were conducted on alternate samples. The mean cell count decreased 50% between the earlier and later samples. There was generally a marked decrease in cell count in successive samplings from a quarter and this change was not clearly reflected in the CMT scores. Even in the absence of any detectable infection by microbial pathogens, marked variations in cell count level frequently occur; both within a normal milking of a quarter, and among foremilk samples taken at intervals between milkings. (AH g3-8)

2. Raw milk quality as influenced by rate of cooling. Investigations were continued on the effect of differing rates of cooling in mechanically refrigerated farm bulk tanks on raw milk quality. Studies using milk of a relatively high bacterial count were begun. A small-scale milk handling regime, designed to simulate can storage and transport under conditions of poor sanitary control was used. During each trial a portion of the raw milk from this regime was added to the regular bulk tank supply at each milking.

Studies to date on such milk, containing a natural mixed bacterial flora of approximately 100,000 per ml. (Standard Plate Count), have given results substantially in accord with those obtained on milk of high initial quality. It appears that, on an every-other-day pickup schedule, the cooling rate

can be decreased to the extent that it requires at least 2 hours for the first milking in the tank to reach 50°F. Such a procedure avoids significant bacterial multiplication during the two-day period. These results indicate no justification for the use of maximum blend temperature as a criterion of acceptable milk cooling. This parameter is a very sensitive measure of rate of tank filling, but a most insensitive measure of cooling rate. The cooling rate could be slowed from about 1 to 4 hours and thereby shift the maximum blend temperature by only 6°F. Under minimum satisfactory cooling conditions, judged microbiologically, the maximum blend temperatures were 59 to 60°F., whereas 50°F. is the commonly accepted upper limit. (AH g3-10)

3. Physical methods for fly control.

(a) Effectiveness of electrocutor grids around barns. A method involving electrocutor-grid screens placed in windows plus an indoor electrocutor trap with black light lamps was evaluated for effectiveness in controlling fly populations. Two calf barns where large numbers of house and stable flies were present were used. No substantial reduction of the fly population within the grid-screened barn could be measured unless all major openings were closed or screened. However, many flies were killed by the grids. When animals were allowed access through open doors to exercise lots, the fly populations in the test barn and the "check" rapidly equalized. (AH g3-12)

(b) Face fly activity around cattle. Outdoor behavior of face flies was studied, both on herds in the field and on a single animal confined in a cage with a known fly population. Results indicate that only a small proportion, usually less than 10-15%, of the total face fly population actually annoys cattle at any given time. Female flies visit the animals much more frequently than males, but males cause some annoyance. Three- and five-day-old females visit the cow more frequently than 1-day-old females. The number of flies present on cattle is most closely related to the activity of the animal. The greatest annoyance occurs when the cattle are resting quietly. Although flies visit the face most frequently, they rest on other parts of the body in considerable numbers. An evident peak of activity of released colonized flies occurred early in the morning, but that of wild flies appeared more evenly throughout the day. All flies left the cattle at dusk when natural light levels were still quite high.

Analysis of sightings of individual flies (3-day-old females) caged with an animal indicated a median for the population for sightings on the entire animal of 11.3%, on the face 6.0%, and on the body 2.3%. These same results show that the number of visits made by an individual fly and the duration of these visits are determined by the time interval between visits. When the minimum interval between fly-sightings was at least 10 minutes, each fly made 5.5 visits per day to the entire animal, the average visit being 16.1 minutes in length; however, when this minimum

interval between fly-sightings was increased to 60 minutes the number of visits was decreased to 1.6 per fly per day, with an average length of 111.8 minutes per visit. The data varied widely and in some cases the standard deviations for averages exceeded the average.

All these characteristics indicate the advisability of further investigating control measures which affect face flies when they are off the cattle. (AH g3-12)

(c) Activity during sunset and nocturnal resting places. Additional studies of the nocturnal habits of face flies confirmed that they rest on the foliage of trees at night. Although the flies are readily attracted (about 80%) to "black light" ultraviolet in confined spaces, those found resting on foliage at night do not respond in this manner. Electrocutor grid traps with black light lamps placed in trees attracted less than 1% of a released population in 48 hours. (AH g3-12)

(d) Mating activity of female face flies. Laboratory tests of the mating activity of female face flies indicate that sterilized males compete effectively with normal males in mating. Also, females appear to mate only once if they are inseminated during their first mating. Examination of females attempting to remate indicate that only 5-10% had not received any sperm during their first mating. This indicates that use of sterilized males should be effective in preventing reproduction. A laboratory trial using a ratio of 8 sterilized males; 1 untreated male, and 1 female resulted in a 94% reduction in pupae. (AH g3-12)

(e) Monochromatic light studies. Additional tests of the responses of a 3-day-old female face fly to monochromatic light confirmed that black light ultraviolet is highly attractive under conditions of confinement, and that wave lengths in the red and yellow spectral regions are unattractive. (AH g3-12)

4. Environmental influences on production. Feeding, management, and production data were collected from 46 DHIA Holstein herds over a 3-1/2 year period at Wisconsin. A total of 155 variables was included in this study to determine the importance of specific environmental influences on production differences among herds. Sixty variables were found to be significantly correlated with herd production, 15 of which were highly significant. These 15 variables were bedding, cow cleanliness, vacuum (deviation from recommendation), pulsation (deviation from recommendation), amount of help while milking, method of stripping, condition of calves, feeding of calves, herdsmanship of dairyman, percent TDN in hay, quality score of hay, date of cutting of hay, pounds of TDN fed per 1,000 pounds liveweight per day, percent days herd is in milk, and herd size.

As much as 65% of the variation in herd average milk yield was found to be associated with 10 of these influences. Sixty percent of this variation was associated with herdsmanship, percent days in milk, TDN level, herd

size, pulsation, vacuum, and hay score.

Many of the environmental factors previously assumed to be important determiners of production were found to be unimportant in this study. Such an example is the average interval from udder massage to milking (mean = 2.8 minutes). While this field study may not have adequately measured each of the 155 variables, it was apparent that cows have the biological capacity to react and adjust favorably to generally superior feeding and management practices. They do not necessarily react favorably to certain specific practices which are not implemented according to accepted recommendations.

The use of the environmental index composed of 7 variables appears to bring about marked reduction in variation between herds and hence appears to have considerable potential for use in increasing the reliability of sire appraisals. However, the environmental index will require further testing before extensive field and research use is justified. (AH g5-1)

5. Social relationships among dairy cows. Two groups of 12 cows each were observed in a feed lot for 5 consecutive days and for a second 5-day period one month later. Three observers recorded agonistic behavior according to the categories of contact(excluding use of the head), bunting, forceful, non-forceful and pushing. From the 3,463 contests observed, dominance values were computed for each of the five categories. A social order was established within groups, combining all observations in all categories. Estimates of repeatability for dominance values were .97 from day to day in the same week, and .95 from day to day in different weeks. The data indicated that a definite social order did exist in an established group of dairy cows. Since this order was stable over a period of time, one day's observations can determine this social order. (AH g5-1)

6. Influence of management practices and environmental factors on adaptability

(a) The value of permanent pastures during the summer months for lactating cows. At Louisiana cows receiving alfalfa hay and concentrate showed only a slight decline in milk production during the summer months, whereas, cows on permanent pasture as the sole source of roughage showed marked declines in milk yield with advancing season. The digestibility of pasture herbage was high during the early part of the growing season (April-May); followed by a significant decline during June, July, and early August; and then a slight increase in late August. There were significant positive correlations between quality score and crude protein, quality score and gross energy, and between crude protein and gross energy. However, low correlations were obtained between milk yield and pasture score and between milk yield and crude protein. The correlations between quality score and mean daily temperature, and quality score and lignin of the plants were negative. (AH g4-3)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

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AREA NO. 8: POULTRY - BREEDING

Problem. Poultry breeders have made tremendous progress in recent years through the application of new genetic principles revealed by basic research. Improvement in many of the economic traits has attenuated and new methods of releasing useful genetic variation are needed. Information is needed as to the relative rates of progress which will result from various breeding systems for improving such economic traits as egg and meat production. Furthermore, information is needed as to whether different breeding systems are required or are more efficient at different stages of the breeding program. In order to design the most efficient breeding systems, knowledge of the heritabilities, genetic correlations between traits, and the effects of genotype-environment interactions are required. Information on the cytogenetics of the fowl is seriously lacking and is needed for continued progress. The biochemical and physiological basis for the action of certain genes is unknown and information regarding these processes would lead to a better control of heredity for optimum performance. The economics of production should be improved through knowledge gained on the genetic aspects of feed utilization and on selection under various stress conditions.

USDA AND COOPERATIVE PROGRAM

This is a continuing long-term program involving basic and applied studies of the inheritance of egg production and broiler characteristics. Scientists with majors in genetics, cytology or biochemistry and minors in physiology or statistics are involved. Much of the research is conducted within the framework of four regional projects. In addition to major contributions to the establishment and maintenance of central facilities, the USDA also provides coordinating personnel located at Athens, Georgia; Lafayette, Indiana; and Beltsville, Maryland. The close working relationship between the USDA and State experiment stations in the four regional projects provides for integrated research on a large scale without duplication of effort. Research at Beltsville, Maryland, involves the selection of lines under stress of nutritional deficiency and selection for differences in feed utilization efficiency. A study of genetic, biochemical and physiological differences between these lines is also in progress. Selection for response in egg production to "18-hour" days is conducted in cooperation with AERD. Research in the North Central region is primarily on egg production traits and is done at the Regional Poultry Breeding Laboratory, Lafayette, Indiana, and at 12 cooperating State experiment stations. In the Southern region the emphasis is divided between egg and broiler traits and the work is conducted at the Southern Regional Poultry Genetics Laboratory, Athens, Georgia, and at 14 cooperating State experiment stations. The work in the Northeastern region involves the improvement

of chickens through genetic and physiological studies and is conducted under cooperative projects at 11 cooperating State experiment stations. Cooperative work on reproductive problems of turkeys is carried on with three Western States.

Public Law 480 research projects are in progress or have been initiated as follows: The Animal and Poultry Breeding Department, Ministry of Agriculture, Dekki Gisa, Egyptian Region, U.A.R., is conducting a study to improve and evaluate the Fayoumi and Dandarawi fowl. A study of the effect of environmental stresses on *Tribolium* is being conducted in Spain at the Instituto Nacional de Investigaciones Agronomicas, Madrid, Spain. The Hebrew University, Faculty of Agriculture, Rehovot, Israel, is studying bacteriological problems involved in artificial insemination of hens. A study to evaluate native Indian fowl as new sources of germ plasm is being conducted by the Punjab Agricultural University, Ludhiana, India.

A total of 7.0 professional Federal man-years is devoted to this program annually. Of this number 3.9 man-years are devoted to genetics and inter-relations of performance traits, and 3.1 to selection and systems of breeding.

PROGRAM OF STATE EXPERIMENT STATIONS

Considerable poultry breeding research is cooperative in the regional poultry breeding projects. NC-47 is concerned with the evaluation of different breeding systems, primarily for egg production. Scientists in NE-51 are examining several physiological traits in relation to the genetics of efficient production of eggs and meat. S-57 is designed to evaluate the relative importance of genetic-environmental interactions in meat production and egg production phases as well as environmental effects on parent flocks. W-78 is concerned with the influence of altitude on the genetic capabilities of turkey reproduction. The contributors to regional projects make use of randombred populations as genetic controls, and the effectiveness of these controls is being evaluated.

Research emphasis is given to quantitative genetics and selection under stress. Fertility, hatchability and other reproductive problems are studied intensively, especially in turkeys. Some stations are concerned with the genetics of disease resistance. Breakthroughs of production ceilings are sought using cell irradiation, different lighting regimes, and new biochemical measurements. Experiments on cytogenetics of poultry promise new knowledge of the chromosome complement and identification of some of the known linkage groups with their particular chromosomes.

The total State scientific effort devoted to poultry breeding research is 50.0 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Genetics and Interrelations of Performance Traits

1. Genetic aspects of nutritional deficiencies. Selection has been practiced for four generations for fast and slow growth rate on both a methionine deficient diet and a normal diet. Progress has been made with the divergent selection on both diets as compared to a randombred control population. The chicks reared on the deficient diet had a growth rate at 3 weeks of age of less than half that of chicks on a normal diet. Large differences were observed between the selected lines. Chicks reared to 3 weeks on a deficient diet did not compensate for the reduced growth when fed a normal diet from 3-through 8-weeks. Preliminary evidence indicates little or no difference among the lines in methionine requirement. (AH el-48)

2. Biochemical basis for genetic differences in growth rate. Lines of chickens established by selection for fast or slow growth on a methionine deficient diet do not differ in either methionine or protein requirements. In addition, little difference in growth rate is observed when chicks from each line are fed equivalent quantities of feed. These results indicate that selection progress on a methionine deficient diet is accomplished through a mechanism involving heritable differences in feed consumption rather than efficiency of nutrient utilization. Progeny from 4 dam families within each of 25 sire families were tested for differential growth performance when each dam family was provided daily with an identical quantity of methionine deficient diet. Three-week body weights indicate that the chicks from the best sire family gained an average of 71 grams while the chicks from the poorest sire family gained an average of 59 grams. A sire component analysis showed that the heritability estimated for efficiency of gain on identical quantities of methionine deficient diet was 0.66. (AH el-52)

3. Selection for egg production under sub-circadian periodicities. Egg production for the third generation of White Leghorns selected under 18-hour "short days" continued to show a small increase over previous generations. Hen-day percent egg production was 1.8 and 3.4 percentage points greater than the previous year for the 18-hour and control population, respectively. Egg production for both populations was 4.5 percentage points greater than the randombred control when measured as percent deviation from the randombred control. Differences noted in the third generation, between the 18-hour and control population continued to be of low magnitude. Birds in the 18-hour population, however, continued to be lighter in body weight at 8 weeks of age and reached sexual maturity later than the control population. (AH el-47)

4. Genotype-environment interactions. Studies to identify specific genotype-environment interactions in both egg and meat production stocks were conducted as a part of the Southern Regional Poultry Breeding Project. Recently two trials were conducted with experiment station meat stocks housed at different growing locations (States) under one-half and one square foot of floor space per bird. Data were analyzed separately by sex. Genotype (stock) by environment (locations, floor space treatments) interactions were not significant. Stock by trial interactions were significant at eight weeks of age, but made up only 2.7 and 1.0% of the total variation for males and females, respectively. Studies with egg and meat production stocks are currently being analyzed to estimate the effect of parent flock source and location on the magnitude and relative importance of genotype-environment interactions. (AH el-44)

The North Carolina station tested different genotypes involving both broilers and layers in each of three years at each of three locations. Results with layers indicated highly significant location by year and genotype by year interactions were present for egg production, body weight at sexual maturity, and fall and spring egg weights. Genotype by location interactions were significant for fall egg weight, while the second order interactions were significant for all characters except body weight. The importance of these interactions is reflected in the effect of different testing procedures on genetic progress. (AH el-44)

B. Selection and Systems of Breeding

1. Evaluation of genetic changes produced by various breeding systems.

Studies designed to evaluate breeding systems and selection methods were continued at the central facilities of the North Central Regional Poultry Breeding Laboratory and at five cooperating State stations. Three random-bred control populations are maintained and made available to cooperators as foundation stock and controls. Eggs from these control stocks are shipped to many locations throughout the country upon request. Selection at each station is for one trait, hen-day percent egg production to about 300 days of age. Other traits are observed but are not the basis for selection. Selection pressure in the project is maintained at approximately 25%.

The Indiana station has completed three generations of closed flock index selection (based on sire, dam, and family means) and reciprocal recurrent selection involving the Purdue Pool and the Regional Cornell populations. Third generation tests have also been made of crosses of the index selected lines and of index selection within a cross of the two control populations. These tests indicate little or no progress in hen-day percent egg production from reciprocal recurrent selection or from index selection within the cross. Index selection within the two parent populations and crossing

of the two selected lines seem to show some improvement in egg production. However, it appears that egg size in all the selected lines has decreased. A similar project is in progress at the Kansas Station, except that the Regional Red is used as one of the parent lines rather than the Purdue Pool. Results indicate that family index selection has been more effective than reciprocal recurrent selection in increasing egg production. This difference appears to be relatively consistent for both the selected strains and for their crosses. Data for hen-day percent egg production to 500 days of age is similar to that for the selected trait, hen-day percent production to 260 days of age. Egg size and body weight seem to have decreased in the populations showing increased egg production.

The Missouri station continued the following selection systems through the fifth generation: (1) intraflock in which selection is based on an overall performance index; (2) recurrent selection to three inbred male tester lines (L1, R3, W4); and (3) selection within three Leghorn female lines (La, Lc, Ld). Randombred controls were produced from eggs shipped from the central facilities. Based on survivors production from 22 to 64 weeks, intraflock, crosses from the recurrent selection lines, and within line selection exceeded the control line by 10, 7 and 3 percentage points, respectively. The R3 x Lc cross exceeded the L1 x La and W4 x Ld crosses by 6 percentage points; however, this advantage was evident the first generation and may be due only to superior heterosis. Among the three female lines, the La population was about .5 pounds heavier than the other two, although all three lines were derived from the same base population five generations back and no direct selection has been practiced for body size.

Inbreeding with and without selection was continued at South Dakota and Wisconsin. Selection at Wisconsin has not been effective in offsetting the decline in egg production due to inbreeding. In three of four South Dakota comparisons, selected inbred lines outperformed unselected lines. Other major effects of inbreeding have been delayed maturity, floor laying, reduced body size and high mortality.

Forty-three populations were compared under a common environment at the Regional Laboratory. A sample of 90 birds in three replications of 30 each was tested when available. Sixteen economic traits were measured. The three major control populations, Regional Cornell (CC), Regional Red (RR) and Purdue Pool (PP), continued to remain relatively stable for all traits measured. All of the 15 selection systems based on the CC population ranked above their control in the trait of major interest, hen-day percent egg production to 500 days of age. However, only the individual selection system was significantly ($P < .05$) above the control. It seems that individual selection may be more effective than family selection and that selection for combinability by recurrent or reciprocal recurrent methods may not be effective. However, more data are required for confirmation.

Some possible trends were apparent among correlated responses as the number of selected generations increased. The Iowa High Body Weight line was significantly later in age at sexual maturity ($P < .05$) from all other lines. The sire family selection line tended to be later in age at sexual maturity than the control, whereas the dam family selection line appeared to be earlier. Egg and body weights continue to display some depression as a result of selection for early egg production. Albumen quality seemed to be lowered by selection. Of interest here is the low ranking in albumen quality of the low egg weight and low body weight lines as compared to the high egg production, high egg weight and high body weight lines. A large differential in laying house mortality existed between reciprocal crosses of CC x RR and CC x PP. Mortality was higher whenever CC males were used; 20 percentage points in CC x RR crosses and 8 percentage points in CC x PP crosses.

At the Minnesota Station, the Regional Cornell has been maintained for eight generations in two flocks, one consisting of 50 males and 250 females and the other of 15 males and 125 females. Egg production in the latter flock was somewhat less, which may be due to higher inbreeding. Also, sexual maturity was delayed in the latter flock, with little or no differences in other traits measured. (AH el-43)

2. Randombred control populations. Five randombred control populations were maintained for use by cooperators as a gene pool and as genetic and environmental controls. Three populations are maintained at Lafayette, Indiana, primarily for egg production research and two at Athens, Georgia, for meat production research. Hatching eggs from these stocks are supplied to cooperating universities, to random sample tests, to universities outside the region, and to commercial poultry breeders. (AH el-43, 44)

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AREA NO. 9: POULTRY - PHYSIOLOGY

Problem. Continuing basic research in avian physiology is essential to establish fundamental concepts and to increase the knowledge upon which ultimately must depend the solution of such problems as fertility, hatchability, growth, and egg production. Basic physiological knowledge is necessary also for implementation of the subject matter of other disciplines. In reproductive physiology, for example, the dominant role of the central nervous system is now generally recognized, but much intensive research will be required before we can expect useful knowledge of mechanisms by which the varying actions of external and internal factors are integrated and directed to initiate, maintain, or modify reproductive functions. Many aspects of environmental physiology, of responses to stress, and of growth and development likewise depend upon basic research. On the more immediately practical side, increased knowledge of poultry housing, related equipment, and other management factors is necessary to provide optimal ranges of operational efficiency.

USDA AND COOPERATIVE PROGRAM

This is a continuing program, mainly on basic aspects of the physiology of avian reproduction, but including also applied studies pertaining to environmental physiology and management. In addition to physiologists, the work draws upon geneticists and animal husbandmen. Research is in progress at Beltsville, Maryland, and Glendale, Arizona, the work at Glendale contributing to regional project W-50. Cooperation currently is maintained with members of the Farm Electrification Branch, AERD; Inspection Branch, Poultry Division, C&MS; the National Institutes of Health; and Pennsylvania State University. Under PL 480, a five year project (1964-1969) on the effect of growth hormone on fat metabolism in adult hens was initiated at the Agricultural University, Warsaw, Poland. Federal research in this area calls for 6.0 professional man-years, distributed to subareas as follows: Physiology of reproduction, 4.0; and environmental physiology, 2.0.

PROGRAM OF STATE EXPERIMENT STATIONS

Poultry physiologists are studying the nervous system in order to better control physiological functions. Research on the nerve supply to the ovary and oviduct and the control of blood pressure and the circulatory system is under way. Cholesterol and fatty acid metabolism, biochemistry of egg formation, physiology of digestion and absorption, and taste are under investigation.

Research on growth and development of the embryo includes studies of how fertilization and parthenogenesis trigger embryonic development.

Scientists are probing factors controlling cell growth and the effects of pesticides on embryos.

Endocrine physiology research highlights the thyroid and adrenal glands and the bursa of Fabricius. Interrelationships of these glands with the ovary and testis and the effects of stress are important. Studies of hormonal control of egg laying continue.

Research is extended on the problems of fertility and hatchability. Efforts are continuing in hopes of perfecting a technique to permit long-term storage of poultry semen. Poor fertility is especially important in turkeys and artificial insemination is widely used. Regional project W-50 coordinates research in the western region on environmental factors affecting reproduction in chickens.

The total State scientific effort devoted to poultry physiology research is 51.5 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Physiology of Reproduction

1. Neuroendocrinology. A recent, widely accepted theory of the neuroendocrine control of sequential ovulations in the chicken is based on the assumption that nerve impulses originating from the oviduct during passage of an egg govern the time of release of pituitary ovulation hormone (OH) for the next ovulation. Critical evaluation of this theory has awaited the development of a nonsurgical method for detecting ovulation when the ovulated egg (yolk) does not enter and traverse the oviduct. Such a method, developed at Beltsville, employed time-amplitude ultrasonography of the type used with limited success to detect soft-tissue lesions in humans. Briefly, narrow beams of high frequency sound are pulsed into the ovary from a transducer placed on the body wall. As the sound waves strike the walls of large ovarian follicles, characteristic echos are returned to the transducer, converted into electrical impulses, and displayed as tall upward spikes on an oscilloscope screen. Ovulation is detected by the abrupt disappearance of such spikes from the region of the ovulating follicle.

The ultrasonographic method was used to study the timing of sequential ovulations in hens following transection of the oviduct at the infundibulum to prevent the engulfment of eggs. Two or 3 ovulations were witnessed on consecutive days in each of several operated hens. Since all ovulations occurred within the hours predicted from past records of lay, the results argue against the existence of the postulated oviducal controls on OH release. (AH e3-21)

The hen's coupled ovulation cycle includes a single day of lapse between the terminal ovulation of one sequence and the first ovulation of a following

sequence. The uncoupled cycle is the first to appear at sexual maturity or following an interruption of two or more days. In coupled cycles, the release of gonadotrophic hormone (GTH) for ovulation of the terminal follicle of one sequence appears also to initiate maturation of the first or C_1 follicle of the succeeding cycle or sequence. The maturation course of this C_1 follicle and the timing of release of GTH for its ovulation might conceivably be affected by influences associated with the terminal ovulation of the preceding cycle or with the ruptured follicle or oviducal egg resulting from the terminal ovulation. In the uncoupled cycle, the release of GTH for maturation of the C_1 follicle and subsequently for its ovulation both take place in absence of a preceding ovulation, ruptured follicle, or oviducal egg. Comparison of times of oviposition in 1, 2, and 3 member coupled and uncoupled cycles has afforded some evidence for the conclusion that the release of GTH for maturation of the uncoupled C_1 follicle occurs during a "critical period" incident at about the hour of GTH release for maturation of the C_1 follicle in lengthy coupled cycles. If so, the GTH release for ovulation of the uncoupled C_1 follicle in cycles of 1, 2, and 3 members occurs on the second day following GTH release for C_1 maturation, but earlier in the day by roughly 5, 8, and 9 hours respectively. The most likely means by which this advancement in the hour of GTH release for ovulation of the uncoupled C_1 follicle would appear to be through the action of ovarian feedback hormones on some neural component of the GTH release mechanism.

As part of continuing research on the role of the posterior lobe of the pituitary gland on oviposition in chickens, an examination was made of the long-term morphological and functional effects of removal of the posterior lobe. The results confirmed an earlier report by other investigators that posterior lobectomy leads to persistent diabetes insipidus, but causes only temporary suspension of ovulation and lay. Further, postoperative recrudescence of the ovary as well as resumption of lay appeared to coincide with reorganization of the proximal pituitary stalk into a miniature posterior lobe, a phenomenon observed in several other vertebrate forms but not yet reported for birds.

Examination of the supraoptic and paraventricular nuclei of the hypothalamus, generally regarded as the probable sites of production of posterior lobe hormones, showed that posterior lobectomy led to a rapid depletion of cells in the supraoptic nuclei, involving a maximum of 50% of total cells within 10 days, but had only insignificant effect on cells of the paraventricular nuclei. Conversely, selective removal of the anterior pituitary gland resulted in a marked depletion of paraventricular cells without appreciable effect on cells of the supraoptic region. The apparent association of cell loss with loss of function supports other evidence indicating that in birds, as in mammals, the supraoptic nuclei produce posterior lobe hormones, while the paraventricular nuclei secrete neurohumors modulating anterior pituitary function. (AH e3-21)

2. Reproduction in Japanese quail. A detailed study of ovulation and lay in Coturnix has shown significant differences in the timing of sequential ovulations in this species and in the chicken under a 14-hour light-day. Coturnix ovulate the first (C_1) egg of a sequence at some 8-9 hours after the onset of light, or at about 1 to 4 hours later than ovulation of the terminal (C_t) ovulation in White Leghorn chickens. Lag, or the clockwise difference in times of day between consecutive ovulations, was considerably shorter in Coturnix than in chickens. Total lag, or the difference in times of day between C_1 and C_t ovulations, ranged, in sequences of increasing length, from 1.6 to 2.9 hours in Coturnix as compared to 4.5 to 8 hours for chickens. The origins of these differences are unknown. A demonstration that the intervals from injection of OH preparations to ovulation in Coturnix and chickens are about the same would seem to rule out the possibility that the differences arise from differences in the interval from normal release of OH to ovulation. Other possibilities include differences in the rates of growth of ovarian follicles, or in times of cyclic release of pituitary hormones for maturation or ovulation of follicles. The existence of these differences suggests that Coturnix will be an especially useful subject for comparative studies on ovulation. (AH e3-22)

A method of transbuccal hypophysectomy was developed for Coturnix. The effects of hypophysectomy on the gonads, adrenals, and thyroid glands of the quail were similar to those reported for chickens. A striking difference was observed, however, in postoperative survival between the two species. Whereas mortality in chickens maintained under the most favorable environmental conditions may reach 80% within the first 2 weeks after hypophysectomy, mortality in 40 Coturnix maintained under normal laboratory conditions was less than 5% during the first 30 days. The quail resumed normal activity within 3 or 4 days and appeared hardy enough to withstand shipment to distant points. Assuming that good survival during shipment can be demonstrated, hypophysectomized Coturnix might be made commercially available and thus serve as a convenient and highly useful subject for endocrine studies in birds. (AH e3-22)

3. Parthenogenetic reproduction. A total of 6521 unfertilized Beltsville Small White turkey eggs were examined for parthenogenesis during the 1965 test period, January - May. These eggs were produced by 106 young, virgin hens representing 7 sire families. The average incidence of parthenogenesis of all eggs tested was 43.2%. The incidence of parthenogenesis in eggs of hens from the 7 different sire families varied from 39.5% to 47.1%.

A total of 708 unfertilized eggs contained well-developed embryos, of which number 223 or 31% survived for 20 days or longer within the shell. Fifty three parthenogenetic poults were hatched. These came from eggs of 31 of the 106 hens on test. One hen produced 7 poults and another 5 during the test period. Two of the 31 hens produced 3 poults each while each of 10

others were credited with 2 poults. Each of the remaining 17 hens produced only one poult.

Mortality among parthenogenetic poults continues to be high. Of the 53 poults hatched in 1965, only 9 were still alive on July 1. Perosis, the principal cause of death, appears to be largely of a hereditary nature. General muscular weaknesses, morphological abnormalities, and heart and circulatory involvement were likewise factors contributing to the heavy mortality. (AH e3-19)

Freshly laid unfertilized eggs from a number of different breeds, varieties, and strains of chickens were incubated for 8-10 days and subsequently broken and examined macroscopically for parthenogenetic development. Marked differences were found among chickens of different breeds and strains in their ability to produce eggs capable of undergoing parthenogenetic development. No parthenogenetic development was detected in eggs produced by Araucana, Old English Black Breasted Game, and New Hampshire hens. A very low incidence of parthenogenesis (less than 0.2%) was encountered in eggs from Barred Plymouth Rocks, Rhode Island Reds, and White Leghorns. The highest incidence of parthenogenesis (6.38%) was found in eggs of the Beltsville strain of Dark Cornish, eggs of the Silver Cornish ranking second with 2.26%. Eggs of two commercial strains of Dark Cornish showed 0.66% and 0.38% parthenogenesis. Of the 1143 eggs classified as having undergone parthenogenetic development, only 6 were produced by breeds of chickens other than Cornish and Cornish crosses. It is concluded that parthenogenesis, to a large degree, is under some sort of genetic control. (AH e3-19)

4. Homograft reaction and immunological tolerance. The graft versus host splenomegaly response in embryos is being utilized to study the effect of sex on histocompatibility in turkeys. In a first experiment, 0.3 ml. of adult male or female heparinized blood was placed on the chorioallantoic membrane of randomly selected 17-day turkey embryos. At 26 days incubation, all embryos were autopsied and their spleen weights recorded. The number of observations and mean spleen weights for the 4 donor-host combinations were: 21 male to male = 26.43 mg., 34 male to female = 26.27 mg., 34 female to male = 23.78 mg., and 22 female to female = 16.22 mg. Mean spleen weights for control embryos which received heparinized saline were: males 14.85 mg. and females 14.11 mg. The fact that the mean weight of all groups except female to female were considerably higher than the mean control weights suggested that the sex of either host or donor might influence histocompatibility. However, there were many embryos in each group which gave no indication of splenomegaly. In hopes of reducing the number of unresponsive embryos the experiment was repeated, this time using embryos from 9 pedigreed matings and injecting 0.05 or 0.1 ml. of blood directly into the chorioallantoic vein of 97, 19-day embryos. Controls received injections of heparinized saline. Splenomegaly occurred in only 18 of 36 embryos from three hens, while all embryos from the other 6 hens

were entirely unresponsive. The number of responding embryos was too small to support conclusions about differences between the 4 donor-host sex combinations. However, the fact that 10 embryos which received male blood had an average spleen weight of 292.82 mg. while the 8 which received female blood had an average spleen weight of 109.12 mg., indicated that the degree of splenomegaly may be related to the sex of the blood donor. The most interesting observations were (1) that embryos from only 3 of the 9 hens bore histocompatibility antigens different from either of the blood donors and (2) that of their 36 embryos, 18 developed splenomegaly and 18 did not. This 1:1 relationship suggests that the splenomegaly syndrome in turkeys may be controlled to a great extent by a single segregating histocompatibility locus. We expect to pursue this interesting lead in subsequent research. (AH e3-20)

Preliminary data indicate that cross-fertilization of Beltsville Small White turkey hens with Dark Cornish chicken semen may be blocked by prior intraperitoneal injections of the hens with the specific chicken semen. Fifteen virgin turkey hens - five groups of 3 full sisters - were placed in individual laying cages and brought into egg production in late January 1965. Two sisters of each triplet were to be injected later with Dark Cornish chicken semen and one sister of each triplet was to remain uninjected. Still later all were to be inseminated with semen from Dark Cornish males. Five different Dark Cornish males were used, each one assigned to a triplet as its specific semen donor for injection and insemination. Through 85 days preceding insemination a careful check was made of the incidence of parthenogenetic development in eggs laid by all hens. Those 10 to be injected laid 540 eggs, 76 (14.1%) of which showed parthenogenetic development after 9-11 days incubation. The 5 to remain uninjected laid 258 eggs, 44 (17.1%) of which showed similar parthenogenetic development. In the four weeks immediately preceding insemination two hens of each triplet received, twice each week, an intraperitoneal injection of at least 0.2 ml. Dark Cornish chicken semen in complete Freund's adjuvant.

Four days after the last injection all hens were artificially inseminated with at least 0.05 ml. undiluted semen. Seven identical inseminations followed at weekly intervals. In the 8-day period immediately following the first insemination, 3 of the 5 uninjected hens each produced one hybrid embryo which survived approximately 22 days incubation. No more were produced by these hens in spite of subsequent inseminations. No identifiable hybrids were produced by the injected hens throughout the total 63 days following the first insemination. During 33 days immediately following the first insemination, the combined incidence of hybrid and parthenogenetic embryonic development in eggs from the uninjected hens rose to 51.1% (47 of 92) while there was only a slight increase to 25.9% (51 of 197) in those from injected hens. In the final 30 days, development dropped to 18.7% (14 of 75) in eggs from uninjected hens and to 18.5% (29 of 157) in eggs from injected hens. Aside from apparently having inhibited hybridization of these two species by the specific intraperitoneal

injections, it was also interesting to note that cross-fertilization could not be maintained in the uninjected hens in spite of continued weekly inseminations. (AH e3-20)

5. Eggshell pigmentation in Japanese quail. The eggshell pigments of wild-type and mutant white-egg Japanese quail have been identified by spectrophotometric analysis of eggshell solutions, solutions of wild-type superficial pigment alone, and extracts of uterine tissue. Solutions of wild-type eggshells, without superficial pigment, in methanol - HCl (4:3) had optical density peaks at 380, 415, 560, and 680 m μ . Solutions of wild-type superficial pigment alone, in the same solvent, had optical density peaks at 415 and 560 m μ . Extracts of wild-type uterine tissue in 3N HCl showed optical density peaks at 410 and 560 m μ . Similar solutions of white eggshells had low optical density peaks only at 415 and 560 m μ and similar extracts of mutant uterine tissue had low peaks only at 410 and 560 m μ . Dissolution of eggshells in 3N HCl shifted the principal absorption peak from 415 to 410 m μ and extraction of uterine tissue in methanol - HCl shifted the same peak from 410 to 415 m μ . Red fluorescence of all extracts and solutions in ultraviolet light specifically indicated the presence of porphyrins. Comparison of these data with known optical density spectra indicated that both oöporphyrin (absorption maxima at 411 and 557.2 m μ in 25% HCl and 410 and 560 m μ in 3N HCl) and biliverdin (absorption maxima at 377 and 680 m μ in 5% HCl in methanol) were responsible for the pigmentation of wild-type eggshells. The slight pigmentation of white eggshells appeared to be due solely to small amounts of oöporphyrins since no biliverdin was detected on them or in mutant uteri. Thus the phenotypic difference between wild-type and mutant white-egg quail seems based on (1) a qualitative lack of biliverdin in white eggshells; and (2) a quantitative difference in the amount of oöporphyrin in and on the eggshell of both types. (AH e3-25)

Utilizing quail hens which tend to lay at the same hour each day in long uninterrupted sequences, it has been determined that superficial eggshell pigment deposition begins between the second and third hours prior to oviposition. At hourly intervals, beginning six hours prior to oviposition, such hens were autopsied and the presence or absence of superficial pigment on the eggshell surface of the uterine egg was recorded. Simultaneously, a 1 gram sample of uterine tissue from each of 3-5 hens was extracted and its optical density at 410 m μ was recorded. No superficial pigment was observed on 24 eggs removed from the uterus 4-6 hours prior to oviposition. Likewise, 12 of 17 eggs removed 3 hours prior to oviposition had no superficial pigment, although the remaining 5 did show slight darkening in the shell pores. By 2 hours prior to oviposition 13 of 13 eggs were superficially pigmented, 12 heavily and 1 moderately. Five of five eggs at 1 hour prior to oviposition were heavily pigmented. Similarly, there was an abrupt decrease in the mean optical density of uterine tissue extracts between the third and second hours, with the mean optical density at 2 hours prior to oviposition only 41.5% of that at 3 hours. (AH e3-25)

B. Environmental Physiology

1. Photoperiod, fertility, and molt in turkeys. In connection with work on the influence of length of photoperiod on turkey reproduction, the molt of naturally mated Beltsville Small White toms was studied. Preseasonal molts of 20% or more seldom occurred in males not exposed to artificial light or exposed to an initial photoperiod of 11 hours, but occurred regularly in March, April, and May in males under 13- and 15-hour initial photoperiods started the previous December. However, there appeared to be no consistent relationship between these preseasonal molts and subsequent fertility. In only one of six groups of males under 13- and 15-hour photoperiods was preseasonal molt followed closely by a definite decline in fertility, although declining fertility was observed regularly following the "normal" summer molts occurring in June, July, and August. (AH e3-18)

2. Effect of light intensity on egg production. White Leghorn pullets hatched in March were maintained under 16 hours light daily. Supplemental light from 40-watt bulbs was supplied to all birds from hatching to about 20 weeks of age. Thereafter duplicate groups received supplemental light from 15-, 40-, 300-, 500-, and 1000-watt bulbs. Egg production differed little in hens under supplemental intensities afforded by 15- to 500-watt bulbs, but was lowered appreciably in groups receiving supplemental light from 1000-watt bulbs. (AH e3-23)

3. Light intensity and cannibalism. The effect of dim light on cannibalism was studied in White Leghorn hens confined in 24" x 18" cages, five birds in each. Two hundred hens in a "closed" house (wood walls, no windows) received light, 16 hours daily, from 15-watt bulbs. An additional 200 hens in an "open" house (walls of wire mesh) were exposed to daylight supplemented after sunset with light from 40-watt bulbs to give 16 hours illumination daily. Half the hens in each house were debeaked, half remained intact. The experiment was terminated at the end of 196 days because of failure of "foggers" in the open house. No deaths from cannibalism were recorded among debeaked hens in the closed house and only 2% among debeaked hens in the open house. Among the intact hens, losses from cannibalisms amounted to 15% in the closed house, 94% in the open house. The experiment will be repeated. (AH e3-23)

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AREA NO. 10: POULTRY - NUTRITION

Problem. The goal of nutrition research is to amass information so that poultry diets may be formulated and fed to produce the best quality product at the least possible cost. The problem logically divides into two areas: (1) furnishing the nutritive requirements of poultry, and (2) the feedstuffs that supply these requirements. A refined methodology is needed to estimate more accurately the energy (carbohydrates and fats), protein (amino acids), vitamin and mineral requirements of poultry of various ages, strains, and levels of production. Even more urgently needed is information on the relationships that exist between these nutrients, if the formulation of optimum nutritive balance in diets is to be attained. Additional information is required on the effect of feed additives (antibiotics, arsenicals, hormones, enzymes, antioxidants, tranquilizers) on nutritive requirements, and on the utilization of protein and energy. Somewhere in the maze of requirements, interrelationships, and interactions, it must be determined which portion of the diet is for intestinal microorganisms and which is for the host. Also, the vast field of interrelationships between disease and nutrition remains to be explored. In the feedstuffs area, how much of a particular nutrient that is present should be known, but of more importance is how much is available to the bird. Thus, information on digestibility, absorption, chelation, and interactions is necessary. In addition, the complete composition of a feedstuff must be known. At the present, the proximate analysis is the only information available about major dietary constituents; consequently, the nutritionist does not know exactly what is being fed when a diet is formulated. There may be present growth promotant and/or inhibitors of which he is not aware.

USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by nutritionists on basic and applied research on the nutritive requirements and digestion and metabolism of poultry and the nutritive value of feedstuffs. The work is in progress at Beltsville, Maryland, and at the Southwest Poultry Experiment Station, Glendale, Arizona. Some phases of work at Glendale are carried on in cooperation with the Departments of Biochemistry and Poultry Science of the University of Arizona at Tucson.

A project to study malathion residues in poultry meat and eggs was contracted to Iowa State University of Science and Technology, Ames, Iowa. Its duration is for three years, 1965-1967.

Studies concerned with the influence of different factors on metabolism of vitamin A in chickens are in progress at the Hebrew University, Israel. Its duration is for five years, 1962-1967, and involves PL 480 funds. A project for the evaluation of the protein quality and energy values of feedstuffs available in India is in progress at Punjab Agricultural University, Ludhiana, India. Its duration is for five years, 1964-1969 and involves PL 480 funds. Investigations on calcium and phosphorus metabolism in chickens and factors influencing shell quality are in progress at the National and University Institute of Agriculture, Rehovot, Israel. Its duration is for five years, 1964-1969, and involves PL 480 funds.

The Federal effort devoted to research in the poultry nutrition area totals 6.3 professional man-years. Of this number 2.3 are devoted to digestion and metabolism, 1.6 to nutritive values of feeds, and 2.4 to nutritive requirements.

PROGRAM OF STATE EXPERIMENT STATIONS

Protein, energy, mineral, and vitamin requirements for maximum production and efficient feed utilization of chickens and turkeys are being investigated. Other aspects are concerned with changes in the nutritive requirement brought about by dietary nutrient interactions or interrelationships, genetic differences as related to nutritional needs, nutrition of mature hens to extend productive life and prevent reduction in production as age increases. Feedstuffs are being evaluated for nutrient availability, particularly amino acids. The effects of physical, enzymatic, and chemical treatment on nutrient availability are being studied. New antibiotics are being evaluated for growth promoting ability. Fundamental studies underway are designed to yield information on dietary factors controlling cholesterol biosynthesis, chemical structure of unidentified growth factors, trace mineral metabolism, particularly zinc, dietary components that effect the incidence of aortic rupture in turkeys, and the effect of anticoagulants and vitamin K on the incidence of blood spots in eggs.

Management practices that affect performance of laying hens, such as, nutrient and/or light restriction during the growing period, housing density in cage or floor pens, and controlled or natural environmental temperature are being studied. Broiler research is concerned with the effects of heat stress and housing density on growth rate and feed efficiency. The effects of bird density, litter condition, air movement and temperature control on rate of growth and reproductive performance of turkeys are also being studied.

The total State scientific effort devoted to poultry nutrition and management is 109.00 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Nutritive Requirements

Linoleic acid studies were continued. Pullets were reared from hatch to maturity on the purified diet which has been used for several years to produce a severe linoleic acid deficiency. Starting at maturity they were fed the purified diet plus 4% linoleic acid. The egg production and egg size was about the same as that normally expected of pullets maintained on the purified diet plus 4% linoleic acid from hatching time. This showed that severe linoleic acid deficiency during the growing period did not affect subsequent performance. However, the production and egg size was significantly lower than that of pullets on a corn-soy diet containing 4% linoleic acid. This indicates that the purified diet is deficient in factors other than linoleic acid. Until these factors are recognized, it will be impossible to pinpoint the linoleic acid requirement of the hen with any degree of accuracy.

Studies on the effect of linoleic acid depletion on the fertilizing capacity of male chickens were continued. When three diets were fed, a purified diet devoid of linoleic acid, the purified diet plus 4% linoleic acid, and a practical diet containing 4% linoleic acid the average fertility was 62, 79, and 82%, respectively. Although the exact requirement of linoleic acid has not been determined, these results indicate that 4% is adequate for fertility. The decrease in fertility did not result from decrease in sperm motility or sperm count, thus metabolic changes in the sperm are indicated.

Studies with female Japanese quail indicate that they respond to a deficiency of linoleic acid in a manner similar to chickens. When quail were fed a purified diet devoid of linoleic acid, egg production dropped from 85 to 40% during the experimental period, whereas quail fed the same diet plus 3% linoleic acid, maintained production between 83 and 94% during this period. The average egg weight of the linoleic acid deficient quail was 16% less than that of the group receiving linoleic acid. Subsequent studies have indicated that 1 to 2% dietary linoleic acid is required for maximum egg production and 2 to 3% is required for maintenance of egg weight. (AH e2-20)

B. Digestion and Metabolism

1. Metabolism of fats. In studies to investigate further the effect of linoleic acid (18:2) on egg production, egg size, fertility, and hatchability, pullets were reared from hatching to 25 weeks of age on a purified diet practically devoid of 18:2. They were divided into six groups and

given safflower oil at increments to furnish zero, 10, 20, 40, 80, and 250 mg. of 18:2/bird/day, respectively. Increase in egg production, egg size, fertility, and hatchability paralleled the increase in dietary 18:2 with the exception that hatchability still remained zero at the 10 mg. level. Only 20 mg. of 18:2 daily were necessary to increase fertility from 73 to 92% and to decrease early embryonic mortality from 31 to 11%. Higher levels of 18:2 had no further effect on these reproductive traits. The presence of substantial quantities of eicosatrienoic acid (20:3) in plasma and yolk lipids of linoleic acid-deficient pullets suggests a relationship between the expression of reproductive traits and tissue level of 20:3. The level of 20:3 in the tissues decreased with each increase in 18:2, and these decreases were reflected by increases in egg production, egg size, and hatchability.

Experiments to study the relationship between the polyunsaturated fatty acids (PUFA) of menhaden oil and linoleic acid on the reproductive characteristics of the hen were conducted. Safflower oil was added to a purified diet devoid of linoleic acid to supply zero, 20, 80 and 1,700 mg. of linoleic acid/hen/day and menhaden oil was added to supply 20 and 80 mg. of linoleic acid/hen/day. The level of menhaden oil supplying 20 mg. of linoleic acid stimulated egg production, hatchability, and egg size to the levels obtained with safflower oil supplying 80 mg. of linoleic acid. This stimulatory effect of menhaden oil cannot be attributed to its linoleic acid content and is apparently due to the PUFA present in the oil. As in all previous experiments concerned with linoleic acid deficiency, the presence of eicosatrienoic acid in the tissues had an inhibitory effect on reproductive capacity. In this experiment the inhibitory effect was evident even in the presence of substantial quantities of essential fatty acids in the tissues. These results indicate that the PUFA in menhaden oil depress the synthesis of eicosatrienoic acid in the linoleic acid deficient hen and negate its effect on reproduction. (AH-e2-13)

2. Metabolism of calcium and phosphorus. Studies on the metabolism of these minerals at the National University, Rehovoth, Israel, show that the major calcium storage in laying hens is in the long bones. When hens were fed a low calcium diet, the ends and medullary segment of the femur lost a considerable amount of calcium during depletion. After three weeks on a replete diet, the initial content of the depleted segments was fully restored. Radioisotopes of calcium and strontium were administered to the hens and it was found that calcium deficiency increased the deposition of the radioisotopes in the eggshell. The data indicate the strontium-85 may be a good in vivo indicator for the movement of calcium. Other studies using radioisotope techniques indicated that most of the calcium absorption takes place in the proximal parts of the intestine. There was very little

absorption in the ileum and colon. In the duodenum there was considerable endogenous excretion of phosphorus. The percentage of calcium absorption was not influenced by the calcium content of the diet, but high dietary calcium depressed the absorption of phosphorus. The percentage calcium absorption was about twice as high during the periods of shell deposition than in periods when no shell was deposited. (A10-AH-20)

3. Utilization and function of vitamin A. Continuing studies concerned with vitamin A at the Hebrew University, Rehovoth, Israel, have indicated that when lutein is dehydrated to form anhydrolutein, a pro-vitamin A₂, two inactive dehydration products are formed simultaneously. These products are in turn converted to anhydrolutein. The in vivo conversion of carotenoids to either vitamin A or A₂ was demonstrated by feeding tests with vitamin A-depleted mice. Studies on the effect of dietary protein levels and supplementation with thyroxine or uracil indicate the following: liver vitamin A depletion was reduced by lowering dietary protein level; protein malnutrition resulted in lowering vitamin A in alcohol form in the liver; depletion of vitamin A in liver was related to the percentage of the vitamin in alcohol form; thyroxine increased both vitamin A depletion from the liver and the percentage of vitamin A in alcohol form, whereas thiouracil had the opposite effect. Low protein levels significantly lowered vitamin A and protein in the plasma. Other studies indicated that the presence of enzymes which destroy carotene decreased the availability of carotene from green plants. Autoclaving improved the stability of carotene in plant tissue. (A10-AH-7)

C. Nutritive Value of Feeds

1. Effects of feeding cottonseed meal. Tests at Glendale in cooperation with the University of Arizona using four meals made from glandless seed and four meals made from glanded seed at 10 or 20% dietary level were conducted at two locations with laying hens. At one location the eggs were stored 15 days at 50-55°F. or three or six months at 35°F. At the other location all eggs were stored 14 days at 42°F. when some were examined and the remainder were stored at 32°F. for a total period of 4-1/2 or 6 months. When the glandless meals were fed at the 10% level, no pink whites were observed at any of the storage periods. At the 20% level one of these meals did not produce pink whites after six months' storage. Discolored yolks were observed with two of the four glanded meals after 14 days storage, and with all glanded meals except one after 4-1/2 and 6 months. Although there was an unexpected high incidence of yolk discoloration from the glandless meals the intensity of discoloration was relatively light. The data indicate that "bound" gossypol was liberated in the digestive tract of some layers.

Other studies at Glendale in cooperation with the University of Arizona showed that when two cottonseed meals, each containing less than 0.1% lipids, 0.02% free gossypol, and about 1% bound gossypol, were substituted at 10 and 20% levels for soybean meal, there was no appreciable egg discoloration. However, when 0.5% cottonseed lipids were incorporated in the diets, a higher amount of discoloration was produced. (AH e2-17)

2. Nutritive value of grains. In tests conducted at Glendale in cooperation with the University of Arizona, the nutritive value of five varieties of sorghum were compared with that of corn in chick diets. Three of the varieties were inferior to corn and two varieties were equal to corn. However, when the diet containing corn was equaled in protein content to the diet containing sorghum, then one of the superior varieties was found to be inferior to corn. (AH e2-15)

Tests were continued to determine the feeding value of corn, wheat, oats and barley. Each of these grains was fed at protein levels of 10, 12.5 and 15%. The diets were isocaloric for each protein level. The four grains were equal in supporting egg production at the 12.5 and 15% protein level. At the 10% protein level, oats was the only grain in both experiments that supported egg production equal to that of the higher protein levels. In the second experiment the production obtained with corn approached that obtained with oats. Feed conversion decreased as the protein level decreased, irrespective of the grain fed, but there was no difference between grains on the different protein levels. There was a positive correlation between protein level and body weight for all the grains. At each protein level the birds fed oats showed the greatest gains in body weight. This phase of the investigation has been completed. (AH e2-14)

3. Amino acid content of feedstuffs. Investigations on methodology of amino acid analyses have shown that the period of time that proteins are hydrolyzed affect the amino acid values obtained. It has also been shown that the enzymatic removal of starch from feedstuffs before hydrolysis prevents the partial destruction of some amino acids during hydrolysis and results in a more accurate estimation of the amino acid content. A new method has been developed for the precise and accurate estimation of tryptophan by chromatographic analysis. (AH e2-16)

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AREA NO. 11: POULTRY - IMPROVEMENT OF VIABILITY

Problem. Leukosis continues to head the list of diseases that cause a high mortality among chickens. It is prevalent in both young and mature stocks, and on most, if not all, farms where chickens are reared. It is also responsible for high rates of condemnation at processing plants and poor performance with respect to growth and egg production.

The yearly financial losses to the poultry industry of the United States from leukosis mortality alone are estimated to be in excess of \$65,000,000. At this time when the margin between the cost of production and the price received for poultry products has been reduced to a very low figure, it is more urgent than heretofore that additional emphasis be placed on research directed towards the development of effective control measures for the leukosis complex. Also, such studies with chickens continue to be invaluable models for research on leukemia in other animals and man.

USDA AND COOPERATIVE PROGRAM

This is a continuing program in virology, pathology, immunology, epizootiology and genetics on basic and applied studies of the neoplasms of the avian leukosis complex. Most of the studies are conducted at the Regional Poultry Research Laboratory, East Lansing, Michigan. Work is also done in cooperation with more than a dozen other Federal, State, or commercial agencies located in several sections of the United States.

The primary objective of these studies is to develop a practical program for the prevention of losses due to the diseases of the avian leukosis complex. Most of the effort has been and currently is directed towards two approaches. The first is to develop a program to increase resistance of the chickens to avian leukosis. It has been found that the level of viral stimulated antibodies and certain yet undefined physiologic mechanisms are genetically controlled and have very important influences on resistance. For significant progress in this approach, it has become evident that basic studies must continue to be conducted on (1) mode of inheritance, (2) mechanism of gene expression, (3) interrelationships of resistance to different tumor viruses, avenues of exposure, and other genetically controlled traits, (4) dynamic interrelationship between infection, antibody, and neoplasms, (5) ultrastructure, biochemistry and the molecular biology of the causative virus and infected cells, and (6) the mechanism of influence of the bursa of Fabricius on neoplasia.

The second approach is directed towards the prevention of infection and/or elimination of the disease. Avian leukosis is a contagious disease. The infectious virus is transmitted not only by direct contact with infected chickens and with infected environment, but also via the infected embryonating egg. The most important prerequisite for progress in the

development of eradication measures is a simple but adequate method of detecting current or past infection. Only recently has notable progress been made on this aspect and further simplification of procedures can be expected. Such fundamental epizootiological information as the extent and prevalence of infection, the modes of spread of infection, the importance of various vectors and reservoirs, the importance of various environmental factors and other concomitant diseases, and the influence of passive as well as active immunity must be obtained before a rational program of eradication can be developed.

Recent developments have demonstrated that there are at least two different families of viruses--not one, as formerly thought--that cause similar types of leukoses. This emphasizes the magnitude of the problem that still faces us.

Research contracts, each for a three-year period, are in effect with Cornell University, the University of Connecticut, and the University of Georgia. In addition, cooperative agreements with at least seven universities or commercial concerns were in effect during the reporting period. Also cooperating in this area of research are the National Institutes of Health, the American Cancer Society, and the Animal Health Division, and the Animal Disease and Parasite Research Division of the Agricultural Research Service.

The Federal scientific effort devoted to the research in these areas during the past year totaled 11.3 professional man-years. Of this number, 2.4 were devoted to in vivo and in vitro studies of the causative agent, 3.0 to immunology and serology, 3.2 to epizootiology, 1.7 to genetics, and 1.0 to biophysics and biochemistry.

PROGRAM OF STATE EXPERIMENT STATIONS

The State agricultural experiment stations are conducting research into genetic, physiological, and nutritional factors affecting the incidence and severity of the avian leukosis complex. Blood group antigens are determined in several populations of domestic fowl varying in degree of resistance and susceptibility to the disease. Relationships between blood antigens and disease resistance are explored. Other research utilizes select viruses of the leukosis complex in an attempt to determine the mode of gene action involved in resistance to the disease. Several serum enzymes are under investigation in populations bred for differences in resistance to leukosis. Also, the effects of protein, vitamin and mineral levels in feed and their relationships to leukosis are examined.

The total State scientific effort devoted to Improvement of Viability in poultry is 2.0 professional man years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. In vivo and in vitro Studies of the Causative Agent

The standard stocks of Rous sarcoma virus have for helper viruses two leukosis viruses identified as RAV-I and RAV-II. These correspond to types A and B respectively of the leukosis virus groups by Dr. Vogt. It was found that RAV-II causes visceral lymphomatosis and osteopetrosis in both inbred line 7 and line 15I. Whereas RAV-I like RPL 12 causes these neoplasms only in line 15I chickens. Erythroblastosis occurred only in line 15I and was caused by both viruses.

These and other data conclusively demonstrate that within the RIF positive group of viruses which cause visceral lymphomatosis (lymphoid leukosis), osteopetrosis, other leukosis and tumors, there are at least 2 distinct subgroups which are separable on the basis of (1) antigenic differences and (2) susceptibility to infection as determined by different gene loci. These findings further emphasize the importance of the use of experimental hosts of known susceptibility to the various viruses or subgroups of viruses under investigation.

Further studies on the role of the bursa of Fabricius in the causation of visceral lymphomatosis have revealed that this malignancy is exclusively of that component of the lymphoid tissue that is derived from and/or dependent for its development upon the bursa of Fabricius. The studies further exclude the thymus or the thymus dependent lymphoid tissue from participation in the pathogenesis of visceral lymphomatosis. Bursectomy can be performed as late as 5 months after viral inoculation and still influence the development of lymphoid tumors. Antibody production, a function of the bursa-dependent lymphoid tissue, is also demonstrated to be impaired early in the development of visceral lymphomatosis.

It has been known that the application of the male sex hormone to the fertile egg either by direct injection or dipping in an alcoholic solution, has a marked effect on the development of lymphoid tissue. In one experiment, one-half of the chicks hatched of fertile eggs that had been dipped in a solution of testosterone had no bursal tissue at necropsy. Of 96 such chickens only one developed visceral lymphomatosis whereas 75% of 86 chickens which had intact bursas, whether or not they were from dipped eggs, developed visceral lymphomatosis. These results point to a chemical means of preventing the development of visceral lymphomatosis, however, this cannot at this time be considered a practical method since the dipping had a marked adverse effect on hatchability. (AH e6-10)

Attempts are being made to establish continual cell lines propagated in vitro from chicken embryos of pedigree matings of inbred lines 15I and 7. Such cell lines will insure genetic continuity and provide a highly reproducible in vitro system for critical studies of the viruses of the avian leukosis complex. Currently, three separate cell lines of 15I and two

separate cell lines of line 7 cells are in continual passage. Line 15I cells are in their 7th, 14th, and 33rd passages. Line 15I cells of the 7th passage gave a Rous sarcoma virus (RSV) titer (2×10^7) similar to 1st or 2nd passage cells. The 14th and 30th passage cells gave titers of 1×10^5 and 5×10^4 cc respectively. Microscopically, cells obtained after the 10th passage appeared more elongated than those of the first few passages, however, morphologic appearance does not indicate transformation. Line 7 cell lines are in the 8th and 13th passages. Both cell lines at the 7th passage were tested for RSV growth. Titers for both were low, i.e., less than 1×10^2 cc. The criteria set by this laboratory for an established cell line is 100 passages or one year in continual culture.

Analysis of human sera from individuals in close contact with poultry has been carried out. Results indicate the presence of anti-RSV activity and a chick embryo cell toxicity factor in the sera. Because of the very high proportion of the samples exhibiting these effects, investigations into the details of collecting and processing the sera were carried out. It was shown that the commercial blood collecting "vacutainers" were contributing to this effect. Types tested included those with red, non-toxic pink, and blue stoppers. In addition, regularly used glass crew-cap test tubes and Erlemeyer flasks were employed. All cell culture systems exposed to sera from those vacutainers with the colored stopper showed evidence of toxicity. (AH e6-24)

The biocharacteristics of the JM strain of leukosis virus, a strain selected as a prototype for RIF-negative leukosis viruses which induce Marek's disease and "acute leukosis" have been studied in line 7 chickens. Transmission of JM virus was routinely successful when cellular virus preparations were given to one-day-old chicks and when uninoculated chicks were raised in direct or indirect contact with JM-inoculated chicks. Transmission with cell-free virus preparation was successful in one of six trials.

Chicks exposed to JM virus by inoculation or direct contact usually developed typical Marek's disease with clinical lameness and paralysis in two to five weeks. The initial deaths in inoculated birds occurred in 18-19 days with a median days-to-death of 28-30 days. Mortality during a 70-day-period for inoculated and contact-exposed birds averaged about 85 and 52%, respectively. These response levels could be increased appreciably by the inclusion of survivors with lesions.

Microscopic lesions occurred before 12 days in inoculated birds and consisted of infiltration of peripheral nerves and spinal ganglia with lymphocytes and plasma cells. A few contact-exposed birds also developed minor lesions in the same interval of time.

Most birds at death had enlarged nerves and about 50% of birds positive by gross necropsy had visceral tumors, principally of the gonad.

Sex did not influence the response to JM virus. Detectable age resistance occurred within four weeks. Potency was largely lost by freezing (rapid or slow). Attempts to propagate the virus in chick ovarian cells have thus far been unsuccessful. The rapidity and ease with which transmission by direct or indirect contact occurs has pointed out the absolute necessity for rigid isolation (isolator cages) for transmission and virus assay trials. (AH e6-30C)

B. Immunity and Serology

The interrelationships between different ages of the host at the time of exposure by different routes to various doses of the RPL 12 leukosis virus and the neoplastic as well as antibody responses were studied in line 151 chickens.

Intravenous inoculation of 10-day embryos or day-old chicks resulted in high early neoplasm mortality with only a few chickens developing antibody. Most of the survivors had a persistent viremia. The latter no doubt was due to an immune tolerance to the virus resulting from infection occurring while the chick was immunologically incompetent. When infection was delayed to 2 or 4 weeks of age, most chickens developed antibodies and died with neoplasms in a variable period depending on dose and route of inoculation. Most chickens inoculated at 16-28 weeks of age developed antibodies, but only a few died of neoplasms. All chickens inoculated intravenously at one year of age developed antibodies, but none developed neoplasms. It would appear that a certain minimum effective dose of virus is required to stimulate the formation of antibodies irrespective of age. A large dose is required to induce neoplasms; in addition, as the chickens become older there is a decrease in susceptibility to formation of neoplasms. The intravenous route is more efficient than the intra-nasal route for induction of infection resulting in either antibody formation or neoplasms.

Comprehensive studies were conducted on the antigenic characterization of several Rous sarcoma viruses (RSV) including RSV (Bryan), RSV (B-high titer), RSV (B-RPL 22), RSV (CT 916), RSV (Harris) and RSV (Schmidt-Ruppin) and RSV to which had been attached the leukosis strains RPL 12, RPL 28, RPL 29, RPL 35 and BAI strain A. All appear to be antigenically related with the possible exception of RSV (Harris). Those leukosis or sarcoma virus strains which originated from RSV (Bryan) appear to be identical antigenically. The two field isolates RPL 28 and 29 are similar to RPL 12 virus. BAI strain A virus is antigenically very complex. Its antiserum neutralizes nearly all viruses tested, but it is neutralized only by its homologous antiserum.

In the course of conducting complement fixation tests for avian leukosis viruses (COFAL), it was observed that some apparently normal embryos and/or cells cultured in vitro reacted strongly in the test. Studies to elucidate the cause of these reactions indicated that genetic factors played an

important role in the presence of this antigen. Based on tests of embryos and culture cells, only certain sire-dam matings resulted in progeny producing a high concentration of this reactive material. Experiments are in progress to determine whether or not a virus, related to the avian tumor viruses, is involved.

Preliminary results of a procedure employing a combination embryo inoculation and the COFAL technique indicate that a very sensitive, rapid assay for strain RPL 12 and/or other leukosis viruses may be developed. This possibility is being investigated further. (AH e6-17)

C. Epizootiology

In cooperative studies with the National Institutes of Health, the occurrence of lymphomatosis and the presence of RIF positive leukosis virus and antibody was followed in samples of commercial and 15I chickens on two commercial farms in Indiana. Farm 1 experienced a relatively high rate of mortality from lymphomatosis and Farm 2 a relatively low rate.

Analyses completed to date indicate the following findings or relationships:

- (a) Maternal antibody in 1-day-old chicks was present in about 1/2 of the chickens of both farms. By 10 weeks of age none had antibody. Line 15I chickens had no maternal antibody.
- (b) Acquired antibody at 6-20 weeks of age was found in about 40% of chickens on both farms, however, among the 15I chickens in contact with the commercial chickens, the number with acquired antibody on Farm 2 was twice that on Farm 1.
- (c) Viremia in day-old commercial chicks due to congenital infection was about 3 times greater in Farm 1 than in Farm 2. At ten days of age the percentage was less than at one day indicating a natural reduction of the congenital infection. The line 15I chickens had no infection at one day, but by 10 days almost 1/2 were viremic. The proportion was higher among those exposed to Farm 1 chickens than those exposed to Farm 2 chickens.
- (d) Viremia measurements of plasma taken at 6, 14, and 20 weeks of age showed that on the averagesomewhat less than 1/2 of the commercial chickens and about 2/3 of the 15I chickens had a viremia. The proportion on Farm 1 was 1.5X higher than on Farm 2.
- (e) Neoplastic mortality was about 3X higher on Farm 1 than on Farm 2.

Differences in the level of infection as indicated by the percentage with viremia, but not by percentage with antibody, appear to be positively

related to the neoplastic mortality in the 2 flocks studied. The higher neoplastic mortality and infection level in Farm 1 may have been due to the much higher congenital infection as evidenced by viremia at 10 days of age.

In attempting to interpret the results of this study, one must consider the possibility that some or even most of the lymphomatosis mortality in this study was not due to the RIF positive viruses which are the only ones detectable by the methods used. (AH e6-27)

D. Biochemical and Biophysical Studies

Rous sarcoma virus preparations have been radio-labeled with tritium. Phenol extraction procedures were used. Low background radio counts indicate that most of the tritium was attached to the nucleic acid of the virus. The nucleic acid fraction gave counts of 300-500/min. whereas those of the protein "coat" were 50 or less. Chicken embryo cell cultures were infected with the radio-labeled virus. Cultures were harvested at various intervals and will be studied with the electronmicroscope using autoradiographic techniques. (AH e6-31)

E. Genetic Studies

Studies of the single gene locus influencing in vivo and in vitro susceptibility to RSV (Bryan) have been extended. It has been shown that this locus has a large effect on susceptibility to erythroblastosis induced by the RPL 12 strain of leukosis virus which is antigenically related to RSV (Bryan). Also homozygous resistant (rs rs) chickens do not produce as much specific antibody after inoculation with RPL 12 as the susceptible chickens (RS RS, Rs rs). This is presumably because the virus does not grow sufficiently in resistant chickens to provide enough viral antigen to invoke an immune response.

The influence of this locus on susceptibility to lymphomatosis under field conditions is under investigation. A second locus influencing susceptibility to other strains of RSV and related leukosis viruses has been suggested by work at other laboratories. Our preliminary data agree with this. Work is now underway to confirm this finding, and to determine the influence of both loci on susceptibility to several strains of leukosis virus.

Studies evaluating inoculation procedures as methods of selection for resistance to field exposure to leukosis have been continued for another year and extended to include studies of resistance to inoculation and contact exposure to isolates of acute leukosis virus. These studies suggest that susceptibility to acute leukosis is independent of susceptibility to chronic types. (AH e6-29)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

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Immunology and Serology

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Genetic Studies

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AREA NO. 12: POULTRY - BROILER LOSSES

Problem. It is necessary to determine the causes of the continuing losses from condemnations - a major problem of the broiler industry. The chronic respiratory disease complex, commonly referred to as CRD or air sac disease is one of the principal causes of condemnations. The presence or absence of pathogenic strains of the pleuropneumonia-like organism, Mycoplasma gallisepticum, largely determines whether chickens will develop air sac disease in the presence of Newcastle disease, infectious bronchitis, or secondary invaders, such as E. coli. Knowledge is needed of the fundamental principles regulating the behavior of the organisms associated with the CRD complex and the host response to them. The great range in host response indicates that genetic variation, nutrition, environment, and management play a part in the severity of the response of individual flocks of chickens. Additional basic information is needed on the effect of stresses on the physiological well-being of the broiler chicken. It is of practical importance to know more of the poultry housing and management factors which adversely affect the bird.

USDA AND COOPERATIVE PROGRAM

A basic and applied program of research directed toward the reduction of losses from broiler condemnations is conducted jointly by specialists in agricultural engineering, animal diseases, poultry management, genetics, biochemistry, and physiology. Two locations are involved in this work, the Southeast Poultry Research Laboratory, Athens, Georgia, and the South Central Poultry Research Laboratory, State College, Mississippi. The Animal Husbandry Research Division's work at Athens emphasizes genetics and physiology in relation to the chronic respiratory disease complex and the work at State College emphasizes environment, management, and nutrition in relation to condemnation losses.

This research program is cooperative with the Animal Disease and Parasite and Agricultural Engineering Research Divisions, ARS. Local cooperation of State experiment stations and the broiler industry in the southeast and south central regions is an important part of the program, particularly with respect to field trials.

The Federal effort devoted to research in this area totals 3.4 professional man-years. Of this number 1.6 is devoted to management practices, 1.0 to genetic control, and 0.8 to environmental physiology.

PROGRAM OF STATE EXPERIMENT STATIONS

Effects of environmental factors on broiler losses are studied at various State agricultural experiment stations. Different materials used in litter

are under investigation. Scientists are developing improved methods of handling and transporting live broilers. Other experiments are concerned with temperature, humidity, ventilation and light in relation to broiler house design.

The total State scientific effort devoted to Environment as related to broiler losses is 8.0 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Genetic Control

In cooperation with the Animal Disease and Parasite Research Division, methods of challenge with Newcastle disease virus (NDV) were investigated to develop an objective technique for identification of resistant and susceptible individuals within the Athens Randombred subpopulation maintained at the Southeast Poultry Research Laboratory.

In embryo-inoculation trials, a mean flock titer to NDV-GB strain for a random sample of 16 replicates was $10^{-8.3}$. Titers were then determined for 75 individual hens in 8 single male matings at the 10^{-8} and 10^{-9} dilutions. Of these, 64 were tested twice and each scored for titer above and below the population mean.

A second series of tests was made on 2-week-old pedigreed chicks from 64 hens, after determination of the mean response by challenge of random groups. In two trials, exposure was by contact with chicks which had been inoculated intratracheally. In a third trial, each chick was inoculated intramuscularly with 0.1 ml. of an LD_{50} dilution of NDV.

Repeatability of results from the same dam across all tests (embryo challenge and chick challenge) was low ($r = .24$). This is not surprising, considering the wide range of phenotypes for color (and presumably genotypes) found in chicks from the same dam in this population.

Initially, sons and daughters of 11 dams, and daughters only of six others, which showed most consistent evidence of resistance by the above tests were saved for reproduction of the F_1 generation of the resistant line. For the susceptible line, sons and daughters of 12 dams, and daughters only of seven others, were saved.

Sons from dams in both susceptible and resistant lines were sacrificed, adrenals and bursae weighed, and blood samples taken to study possible physiological relationships to disease resistance. (AH e7-2)

Two trials were conducted to check the efficacy of polyvinylidene chloride co-polymer resin films (Cryovac) on hatchability of eggs. Eggs stored at 52°C . for three weeks in cartons wrapped in the film hatched 12% better than those stored similarly but without wrapping. This was statistically

significant. In another trial pedigreed eggs from 60 ARB hens were stored for periods from 1 to 4 weeks with and without film wrapping. Two to three fresh eggs per hen were used as controls. Hatchability of fertile eggs was 66.9, 83.3, and 85.3% for the unwrapped, wrapped, and controls, respectively. Although detailed statistical analysis is not complete, wrapping in film improved hatchability of certain hen's eggs more than others. When large numbers of eggs per hen are required in the same hatch, the use of Cryovac-type wrapping appears beneficial.

B. Management Practices

On-the-farm studies of avian nephrosis (gumboro disease) in broilers were completed. The studies show that a curve of mortality is present in a typical outbreak which can be used with clinical manifestations, and with or without the lesions of the disease, as a valuable tool in the diagnosis of the disease. The mortality records involving 2,060,258 chicks started in 209 houses on 28 infected farms showed that the symptoms first appeared at about 25 days of age and lasted about 7.5 days. Mortality usually peaked half way through the active period. The average total mortality was 8.8%, of which 5.6% occurred during the period when avian nephrosis was active. Previous to these studies poultrymen used antibiotics, vitamins, sulfa drugs, and molasses in the drinking water and used detergents, synthetic phenolic disinfectants, quaternary ammonium compounds and lye, with and without litter changes, in an effort to prevent, control, or eradicate the disease. These studies indicated that none of these practices are consistently successful in reducing gumboro disease. (AH e7-1)

Field trials were conducted to determine the effects of feeding a commercial broiler ration supplemented with a dried culture of live Bacillus megatherium. In one trial involving 43,409 chicks the mortality was 7 and 6% respectively for the treated and control groups. In another trial of 50,835 chicks the mortality was 7.5% in the treated group as compared to 4.0% in the controls. (AH e7-1)

Observations were made at constant room temperatures of 70°F. and 40°F., and at 70°F. and 60°F. To date, the trend is for a slightly heavier weight at 70°F. than 40°F., especially during the early stages of growth, but no difference at 70°F. and 60°F. Feed efficiency was always better at the higher room temperature. Comparisons have also been made at these room temperatures between canopy hovers 74 and 99 inches in diameter. There were no marked differences in growth or feed efficiency between the two hovers although the trend was better feed conversion with the 99 inch hover at 40°F. From these data it appears that a constant temperature of 40°F. is not a serious stress in the presence of good management.

There were no consistent differences in growth, feed conversion, livability, or percent condemnation between broilers raised in insulated and non-insulated pens, canopy and infra-red hovers, or when heat was discontinued at three weeks (May, June, July and August). During hot weather there

were no marked differences to six weeks of age between broilers raised in insulated or non-insulated pens, with or without floor fans, or with 0.8 or 1 square foot of floor space per bird. (AH e7-4)

C. Environmental Physiology

A total of 775 pedigreed male chicks from 32 sire families of Athens Randombred stock were screened for their responses at three ages to exogenous administrations of adrenocorticotropin and hydrocortisone. Autopsy data, which included adrenal and bursa of Fabricius weights, have been collected on all birds. Data are currently being analyzed to determine familial differences in the effects of those hormones considered important in the stress response. (AH e7-3)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Management in Relation to Condemnations

Parkhurst, R. T. 1964. On-the-farm studies of Gumboro Disease in broilers. *Avian Diseases*, 8: 584-596. (AH e7-1)

Parkhurst, R. T. 1965. Field experience with Gumboro Disease in broilers. *Poultry Sci.* (Abs.) (In press) (AH e7-1)

AREA NO. 13: SHEEP AND GOATS - BREEDING

Problem. The existence of the sheep industry in this country will depend upon sheep producers being able to effectively and efficiently meet competition from other sources of meat and fiber. To meet this competition the farm sheep producer will need more efficient sheep, sheep which are capable of year-round production of more lambs and wool per ewe, often under adverse environmental conditions and with more resistance to disease and parasites. Range sheepmen need information on genetic methods of improving lamb and wool production. More effective systems of mating, breeding, and selection need to be tested. Breeding studies on reproductive efficiency, inheritance of feed efficiency, rate of gain, and carcass as well as wool quality, deserve emphasis.

USDA AND COOPERATIVE PROGRAM

This is a continuing program by geneticists on basic and applied studies of breeding to increase efficiency of production of high quality lamb and wool. Work in progress at Beltsville, Maryland, involves breed comparisons, studies of gains resulting from crossing of breeds, and selection for increased lamb production. At Dubois, Idaho, systems of mating are compared including development and crossing of inbred lines and selected strains. Also studies on heritability and other genetic parameters of economic traits, as well as studies on improved methods of selection are conducted. At Fort Wingate, New Mexico, and on a private ranch in Utah, selection studies are emphasized. Cooperation is maintained with 15 State experiment stations. Several of the studies contribute to the western, southern, and north central regional sheep breeding projects.

The Federal scientific effort devoted to research in this area totals 5.3 professional man-years. Of this number 1.6 are devoted to genetics and interrelation of performance traits, and 3.7 to selection and systems of breeding.

PROGRAM OF STATE EXPERIMENT STATIONS

Research in sheep and goat breeding seeks information needed for the most rapid genetic improvement of these species. Genetic investigations with sheep include inheritance of carcass characteristics, wool production, and reproductive capacity, performance and progeny testing, selection methods and criteria, early lambing, breed and breed-cross performance, genotype x environmental interactions, and development of superior strains. Wide ranges in breeds are included in several of the studies permitting estimation of genetic variation which occurs between breeds to be utilized in crossing programs and in breed selection. Greater reproductive capacity is of primary concern in many of the studies, and efforts are being made to increase multiple births, improve frequency of pregnancy, and eliminate seasonal breeding. Frequently this approach to greater reproductive rate is from the

genetic aspects or combination of genetics with other disciplines such as nutrition, physiology, or management. In several of the Southern States, for example, early season breeding to produce lambs is being approached through genetic improvement, hormonal treatment, and temperature control.

Research is conducted also under three regional projects; S-29, Genetic and Physiological Factors Affecting Reproduction of Sheep in the South; W-61, Development of Selection Criteria for the Genetic Improvement of Carcass Merit in Sheep; and NC-50, Improvement of Lamb Meat Production Through Breeding.

Active USDA cooperation in sheep breeding investigations is limited to a few State stations and representation of the USDA on technical committees of regional projects.

Genetic investigations with Angora goats for mohair production are being conducted at the Texas station. Evaluation of four selection methods is being made, and estimates of heritability of economic traits and interrelations between traits are being developed.

The total research effort on sheep and goat breeding research by the State agricultural experiment stations is 17.0 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Genetics and Interrelations of Performance Traits

1. Repeatabilities of annual ram records. Data on nine fleece and body traits collected at Dubois over 12 years include observations on 1034 Rambouillet, 742 Targhee, and 412 Columbia rams having at least two and up to five annual records. Repeatabilities were lowest for body type and condition, ranging from 0.3 to 0.5, and highest for body weight, grease and clean fleece weight, and face cover, ranging from 0.7 to 1.0. Values for neckfolds, staple length, and fleece grade were generally in the range of 0.5 to 0.7. Correlations (repeatabilities) among records were estimated as linear regressions of later upon earlier record to minimize effects of selection. The presence of a few estimates exceeding 1.0 indicated that in some instances certain correlations (for weight, face cover, fleece weights, and grade) were overestimated. Also, correlations between pairs of records with differing numbers of intervening years frequently were significantly different, often tending to be smaller as the number of intervening years increased.

Comparisons of pooled intra-year variances of nonselected records made at different ages revealed that variances of many traits were nonhomogeneous over the five ages represented. In particular this was true of face cover, staple length, fleece grade, and fleece weights. In these cases where the variances are importantly different the regression of "true producing ability" on phenotypic average cannot be expressed precisely as a simple

function of the number of records and a single estimate of repeatability, since the differences in variance and repeatability for different records must be considered. (AH b1-6)

2. Productivity of ewes in relation to body size. A study of production records of 80 Rambouillet and 24 head of 3/4 Rambouillet - 1/4 Panama ewes over a 7-year period, in cooperation with the Oklahoma Agricultural Experiment Station, at Fort Reno, Oklahoma, showed that correlations and regressions between measures of body size and production were generally small. Average body weight corrected to a constant condition score was more closely related to the measures of lamb and wool production, than was yearling weight or average lifetime weight. (AH b3-7)

The effect of body weight of ewes on subsequent lamb production was studied using data from Fort Wingate, New Mexico, in cooperation with the New Mexico Agricultural Experiment Station. Birth weights and weaning weights of 805 spring-born lambs were analyzed. Age of dam did not significantly affect the weight of the lambs at birth but the 2- and 7-year-old ewes tended to produce and to wean lighter lambs. Sex and type (single versus multiple) of birth of the lambs exerted the most pronounced effect on the factors studied. Birth and weaning weights were 0.76 and 7.1 kg., respectively, less for twin than single lambs. Twin ram lambs were 0.59 and 1.8 kg. heavier at birth and weaning than twin ewe lambs. There was a 5.63 kg. increase in weaning weight with each kilogram increase in birth weight. The greatest response of weaning weight to the increase in birth weight occurred in the single lambs. The body weight of the ewes markedly affected the weaning weight and, to a lesser degree, the birth weight of lambs. As the body weight of ewes increased there was a significant increase in the weaning weights of lambs. An increase in the ewe's body weight of one kilogram resulted in a .10 kg. increase in weaning weight of the lambs. (AH b1-10, 11, 12)

3. Effects of pregnancy, parturition, and lactation upon wool production of range ewes. Results were published from 2424 records of grease fleece weights during 1955-59 and 1451 records of clean fleece weights during 1957-59 at Fort Wingate, New Mexico. The effects of parturition and lactation were very pronounced. Ewes that gave birth and nursed lambs produced significantly less clean and grease wool than ewes without lambs. The effect of pregnancy was less pronounced than the effects of parturition and lactation. Ewes pregnant with a single lamb did not produce significantly less grease wool than non-pregnant ewes; however, the difference in clean wool yield was significant. These results indicate that wool records should be adjusted for the effects of lactation and pregnancy before being used in a selection program. (AH b1-10, 11, 12; AH b5-6)

4. Relation between purebred and crossbred lambs sired by the same ram. The weaning weights of 1852 lambs from 44 different sires used in the Beltsville flock from 1958 to 1963 were used to evaluate sires as to their ability to produce both superior purebred and crossbred progeny. From a pooled analysis, the sire variance was calculated to be 5.64 pounds and 2.79 pounds for the purebred and crossbred lambs, respectively. The covariance between purebred and crossbred lambs was 3.27 pounds. The correlation between the weaning weights of the purebred and crossbred lambs was 0.82. A correlation this high would indicate that selection of sires for heavier purebred weaning weights would also result in heavier crossbreds. Weaning weight heritabilities for the purebred lambs were found to be 0.26 and for the crossbred lambs 0.12. An average superiority of 8.8 pounds was found between the weaning weight of the crossbred and the parental purebred lambs. This difference is a measure of the hybrid vigor in the crossbred lambs. (AH b1-1, 2, 3, 4)

B. Selection and Systems of Breeding

1. Breed comparisons and crossbreeding. Five breeds of sheep are being compared with respect to their production of wool and lamb as purebreds and their relative merit in a crossbreeding program. The index ranks Targhees (111.5), Suffolks (110.5), Dorsets (102.3), Hampshires (91.7), and Columbia-Southdale (83.2). When an index based on the production per 100 pounds of body weight of the ewe was used, the rank was Dorsets (97.5), Targhees (65.4), Suffolks (63.1), Columbia-Southdale (59.1), and Hampshires (56.1). The index for Hampshire X Merino ewes mated to Shropshire rams was 147.4 and for Hampshire X Shropshire ewes mated to Merino rams was 61.8, compared to 91.3 for purebred Hampshire and 58.0 for purebred Merinos. The indexes from matings involving Merino rams were low because of the low fertility of Merino rams this year. Indexes for Merino ewes mated to Columbia-Southdale rams and Targhee rams were 87.4 and 95.6, respectively. The indexes for Shropshire ewes mated to Hampshire X Merino rams was 72.4, and 116.9 for Merino ewes mated to Hampshire X Merino rams was 72.4, and 116.9 for Merino ewes mated to Hampshire X Shropshire rams. (AH b1-1, 2, 3, 4)

2. New strains of sheep for lamb and wool production. In 1961 work was started at Beltsville, Maryland, to develop a strain of sheep capable of lambing more than once each year. At present ewes of this strain are bred to lamb three times in two years. Lambing times are September, January-March, and May. A total of 272 ewes has lambed since 1961 and these have produced 362 lambs, of which 49 were born dead. The reproductive rate is lowest from breeding in April-May, and highest from breeding in August-October. Lamb mortality was highest in lambs born in September. Sires used in this strain are selected from offspring of ewes having the highest lambing rates. (AH b1-17)

3. Comparisons of breeding systems. Sheep produced at Dubois with mass selection and a minimum of inbreeding (selected control) were superior to those produced in inbred lines or in random bred (stabilized control) groups. Superiority of the selected control group for weanling traits was greater in Rambouillets and Targhees than in Columbias. Selected control groups weaned from 12 to 25% more lambs and 19 to 27 more pounds of lamb, per ewe, than the inbred lines.

Line crossing in the Rambouillet and Targhee breeds produced offspring superior to those from inbred lines, but did little more than to repair the deleterious effects of inbreeding. In these breeds selected control offspring were generally equal or superior to those from line crosses, including lines developed by recurrent selection. Columbia line cross offspring were generally slightly superior to those in the selected control group. (AH b1-5, 14)

4. Effects of inbreeding. Six year averages of the effect of inbreeding on eight weanling traits at Dubois revealed that the traits most affected were weaning weight and possibly body type and condition. Weaning weights were reduced from 4 to 8 pounds, for example, if lambs were 30% inbred and an additional 3.5 to 4.5 pounds if the dams also were 30% inbred. Percent and pounds of lamb weaned per ewe bred were the reproductive characteristics most affected by differences in inbreeding. Each percent inbreeding of dam or lamb resulted in from 0.6 to 1.1% decline in reproductive rate and from 0.6 to 1.1 pounds decrease in pounds of lamb weaned per ewe. (AH b1-5, 6)

5. Testing of inbred lines. Results of the line testing program at Dubois, based on weanling and reproductive data only, show that single trait selection within inbred lines for body weight and staple length has been moderately successful. Such lines are 4 to 5 pounds above the average of all lines in weaning weight and about 0.3 cm. above average in staple length after about 11 years of selection. Selection for body type has been ineffective. Lines selected solely for rapid inbreeding were from 10 to 15% below the average of all inbred lines in percent of lambs weaned by the ewes bred.

A matter of considerable interest is the correlation between the merit of the inbred lines themselves and their merit in topcrosses and linecrosses. There seems to be little evidence that a line's own merit is a reliable index of its topcrossing or general line-crossing abilities. (AH b1-5, 14)

6. Selection for range sheep improvement. To investigate the rate of improvement in wool and lamb production that could be made under practical ranch conditions with a range flock of sheep, a selection program was initiated in 1957 with the Redd Ranches at La Sal, Utah. This project is also in cooperation with the Utah and Colorado Experiment Stations. About 1200 ewes were chosen from 15,000 on the basis of phenotypic merit. These ewes were bred to rams also chosen on the basis of fleece weight, body size,

staple length, open face, and freedom from defects. All ram lambs born in this flock were individually weighed, measured, and scored at weaning time, and the top half saved for possible use in the breeding program. At yearling age staple length has increased an average of .15 inches each year since 1960. Less highly heritable traits, such as body weight and grease fleece weight, have shown no trend in improvement. (AH b1-16)

7. Breed effects on fall lamb production. The performance of Western, Panama, Rambouillet-Merino and Dorset X Western crossbred ewes was compared at Fort Reno, Oklahoma, in cooperation with the Oklahoma Agricultural Experiment Station. The results show that after the first year the Dorset X Western crossbred ewes lamb more readily during the period from October 15 to November 25; produce more twins; raise at least as high a percentage of lambs born; breed more readily from August 20 to September 19, if they do not conceive during late May and June; produce lambs that are as heavy at birth, heavier at 70 days of age, and at market age than the other breed groups with which they were compared. They sheared less wool than the other groups but the wool was usually worth more per pound. (AH b3-7)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Genetics and Interrelations of Performance Traits

Ercanbrack, S. K. and Harvey, W. R. 1964. Interactions affecting weanling and yearling traits of sheep. J. Anim. Sci. 23(3): 848. (Abs.) (AH b1-6)

Galal, E. S. 1965. Correlation between purebred and crossbred paternal half-sibs and environmental factors influencing weaning weight in sheep. Ph. D. Thesis, Iowa State University. (AH b1-1, 2, 3, 4)

Nichols, C. W. and Whiteman, J. V. 1964. Productivity of ewes in relation to body size. J. Anim. Sci. 23(3): 852. (AH b3-7)

Ray, E. E. and Sidwell, G. M. 1964. Effects of pregnancy, parturition and lactation upon wool production of range ewes. J. Anim. Sci. 23(3): 912-913. (Abs.) and 23(4): 989-995. (AH b1-10, 11, 12; AH b5-6)

Stansfield, W. D., Bradford, G. E., Stormont, C., and Blackwell, R. L. 1964. Blood groups and their associations with production and reproduction in sheep. Genetics 50(6): 1357-1367. (AH b1-15)

Selection and Systems of Breeding

Whiteman, J. V., Gould, M. B., Ovejera, A. A., and Thrift, F. A. 1965. The performance of Western vs. Dorset X Western crossbred ewes for fall lamb production. Oklahoma Agricultural Experiment Station Feeders' Day Report, pp. 12-20. (AH b3-7)

AREA NO. 14: SHEEP AND GOATS - PHYSIOLOGY

Problem. Inefficient growth and reproductive failures are costly to sheep producers and cause large reductions in efficiency of production. Additional information is needed on the causes of reproductive failures in the female and low fertility or sterility in the male. Also, more information is needed regarding the basic physiological processes involved in growth and reproduction. The normal physiology of all phases of growth and reproduction must be more thoroughly defined along with the effects of important genetic and environmental factors such as breed, age, season, and level of nutrition in order to develop more effective ways of increasing efficiency. Basic information is also needed concerning the development and growth of fiber follicles in order that further improved practices can be developed for wool and mohair production. This research requires studies on the nature and sequence of histological, cytological, and physiological processes involved in fiber follicle initiation and development.

USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by physiologists and histologists on basic and applied studies of the physiology of reproduction, growth, and development of sheep and goats, including processes involved in fiber follicle initiation and development. Factors influencing mating behavior, estrus, ovulation, and embryonic development in ewes and mating behavior and fertility of rams are directed toward a more complete understanding of the reproductive processes in sheep. The work is in progress at Beltsville, Maryland; Dubois, Idaho; and cooperatively with Idaho and Oklahoma State Agricultural Experiment Stations. Environmental factors affecting growth and development are being studied in cooperation with three State experiment stations. One study contributes to the Western regional project W-46 on the effects of environmental stresses on range cattle and sheep production. Studies on fiber and follicle development of sheep and goats are in progress at Beltsville, Maryland, in cooperation with the Texas Agricultural Experiment Station.

The Federal scientific effort devoted to research in this area totals 1.9 professional man-years. Of this number 1.0 are devoted to physiology of reproduction, 0.1 to environmental physiology, and 0.8 to physiology of wool and fiber.

PROGRAM OF STATE EXPERIMENT STATIONS

The current research program at the State experiment stations in the area of sheep physiology is concerned primarily with attempts to understand the endocrine shifts responsible for the seasonal breeding behavior of sheep and means of altering it. States in the southern region and the USDA are co-operating in regional project S-29, Genetic and Physiological Factors Affecting Reproduction of Sheep in the South, in a study of the various factors important in seasonal and non-seasonal reproduction. Light, temperature, and genetic constitution are receiving major emphasis. Other studies are concerned with determination of abnormalities in the ova which appear to render them incapable of implantation, and nutrition and management factors important in regular reproduction. The technique of ova transplantation has been successfully used in this research.

In an attempt to more accurately assess the effects of stresses of nutrient restriction, altitude, and temperature on growth and productivity of range sheep, the States of the western region and the USDA are cooperating in regional project W-46, The Effects of Environmental Stresses on Beef Cattle and Sheep Production. The stations are comparing full feed and water with varying percentage restrictions along with the influence of altitude, physical nature of the diet, range supplementation, geographical location and temperature as these affect blood chemistry, body composition, wool quality, lamb production, and milk production during the nursing period.

The influence of growth rates of ewe lambs on subsequent production is being studied as is the effect of hormones and hormone-like substances, alone or in combination with antibiotics, on growth and fattening of lambs. A fundamental approach to gain an understanding of the physiology of growth involves a study of the effect of feeding specific metabolites such as sodium propionate upon blood glucose levels and growth rates of lambs.

The total State scientific effort devoted to sheep and goat physiology research is 15.5 professional man-years. An additional 4.0 professional man-years are pertinent to Area 1 (Animal Biology) and are included therein.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Physiology of Reproduction

1. Breeding capacity of rams. In the fall of 1964, 494 yearling ewes were randomized among 8 rams at Dubois, Idaho. These ewes were synchronized for estrus, using oral progestogens in alfalfa pellets and placed with the rams just before the start of the second post-treatment estrus. Other yearling ewes were used as controls. Approximately 73% of the treated ewes were clearly marked during a 4-day period and 62% lambled to the first ram-exposed estrus. In other words, these 8 rams mated an average of about 11 ewes a day for 4 days and about 9 of these ewes lambled. Individual rams settled from a high of 70% to a low of 42% of his assigned ewes at the first exposed estrus.

The breeding performance of the 8 rams mated to the synchronized ewes was 96%; for the 69 rams mated to the control ewes, 89%. (AH bl-7)

2. Effects of light and level of nutrition on reproductive phenomena. Three levels of nutrition (75%, 100% and 150% of National Research Council recommendations) in the form of alfalfa pellets given before and during breeding and gestation had no effect on ovulation rate, but appeared to have an important effect on embryo survival. The percent of embryos in relation to the number of corpora lutea were 57, 66, and 75 for 75%, 100% and 150% of NRC, respectively. The percent embryos of ewes bred were 111, 124, and 150 for 75%, 100%, and 150% of NRC, respectively.

Both dark and intermittent light appeared to reduce ovulation rate below the controls. The effect became greater with increase of days on treatment. Ovulation rate was reduced the most in the intermittent group at each observation point. (AH bl-7)

3. Effect of season on ovulation rate in range ewes. Repeated observations were made on ovulation rate in a group of Rambouillet, Targhee, and Columbia ewes at Dubois, Idaho. The month of observation and corresponding ovulation rate were as follows: October, 179%; November, 197%; January, 160%; February, 112%. A part of the decline in ovulation rate in January and February was due to failure to ovulate in a few ewes (January, 7.7% and February, 22.0%) as they approached anestrus. This seasonal effect on ovulation rate can have important economic implications for the industry as lamb production appears to be highly correlated with ovulation rate. (AH bl-7)

4. Repeatability of ovulation rate and the relationship of ovulation rate to number of embryos or lambs born. The subsequent ovulation rate (one month later) of ewes which initially had only one corpus luteum per ewe was 165% as compared to 206%, 223%, and 250% for ewes which initially had two, three, or four corpora lutea, respectively. Ewes with one versus two or more corpora lutea in October had an average of 1.15 and 1.50 embryos, respectively, per ewe resulting from a subsequent estrus cycle. The percent of embryos of pregnant ewes with either one, or more than one corpus luteum at the initial observation had 154% versus 178% embryos, respectively.

These data indicate that ovulation rate at one estrus cycle is correlated with ovulation rate and the number of embryos developing from a subsequent estrous cycle. It also indicates that ovulation rate one year is associated with the number of lambs born in other years. These results suggest important selection and management implications. (AH bl-7)

5. Repeatability of ovulation response in the ewe to pregnant mare serum (PMS). Ewes at Dubois, Idaho, treated with progesterone, followed by 1000 i. u. of PMS at approximately 21 day intervals showed a marked reduction in ovulation rate with recurring treatments. At first, second, third, and fourth treatments the average number of corpora lutea were 5.23, 2.27, 1.74, and 0.71, respectively. The ewes were divided into three similar groups after the third treatment. One group was given no PMS, one 1000 i.u. and one 2000 i.u. following progesterone priming. The ovulation rates were 0.00, 0.71, and 1.14 corpora lutea per ewe, respectively, for each of the three treatments. (AH b1-7)

6. Relationship between the exhibition of estrus in ewe lambs and their subsequent production. Approximately 15% of the Rambouillet, Targhee, and Columbia ewe lambs at the U. S. Sheep Experiment Station show estrus the first winter. The average subsequent lamb production of those showing estrus the first winter excelled those which did not show estrus by about 10 pounds, per year, per ewe. Wool production appeared to be unaffected. The "estrous ewe" also remained in the flock longer than the "no estrous ewe." (AH b1-7)

7. Pregnancy diagnosis and predicting the number of embryos in the ewe. At Dubois, Idaho, 150 ewes approximately 28 days post-breeding, were laparotomized and palpated for pregnancy and for the number of embryos per ewe. After each prediction was made one or two small incisions were made in the uterine horns and the conceptus removed. The entire operation, including removal of the conceptus and suturing of the uterus, required only 6 to 8 minutes per ewe. Ninety-four percent of the ewes predicted to be pregnant had normal appearing embryos. Membranes and or fluid were removed from the uteri of the other ewes. Most of these membranes contained degenerating embryos. The average numbers of embryos per ewe and per pregnant ewe for those predicted to have one embryo were 1.06 and 1.23; two embryos 1.76 and 1.84; and three embryos 2.50 and 2.50, respectively. The efficiency of the laparotomy technique and the high predictability of the number of embryos present suggest that some practical application of this technique could be made. (AH b1-7)

8. Fetal electrocardiography in livestock. Over 350 fetal electrocardiographs have been made on 50 pregnant dairy cows at Beltsville. Pregnancy and four multiple births were readily detected with all cows during the last one-third of gestation, and in many cases, as early as mid-term. The average fetal heart rate decreased as pregnancy advanced while the average amplitude of the fetal R wave increased. Detection of pregnancy in dairy goats also has been made as early as mid-term, however, more technical difficulties have been experienced than with cows because of the highly nervous temperament of many does. Anaesthesia of the does during the recording appears to offer promise. Fetal electrocardiographs have been made on numerous fetal lambs; however, more refinements of the techniques are needed before the procedure can be used for the routine detection of pregnancy in ewes. (AH b3-12)

9. Estrus control in farm sheep. The breeding flock at Beltsville was divided into three groups prior to breeding in 1964 to test the use of estrus synchronization and thus permit more efficient management at lambing time. One group was fed an oral progesterone (MAP), another group was exposed to vasectomized rams, and a third group served as a control. No difference in lambing time was found among the three groups and the proportion of ewes not lambing was slightly higher for the treated groups. It may be that the treatments were applied before the onset of the breeding season in the breeds of sheep involved. (AH b1-8)

B. Environmental Physiology

1. Response of Targhee sheep to different environments. A study of the productivity of Targhee sheep, in cooperation with the Wisconsin Agricultural Experiment Station at Spooner, Wisconsin, showed 155% of the lambs weaned of ewes bred over a 3-year period. This was higher than for Shropshire and Suffolk matings at the same location and also excelled the lamb production of Targhee sheep at Dubois, Idaho; Fort Wingate, New Mexico; and Beltsville, Maryland. The Targhees were particularly outstanding for low mortality from birth to weaning. Wool production of Targhees at Spooner, Wisconsin, exceeded that of Shropshire and Suffolk sheep at the same location and was comparable to that of Targhee sheep at other locations. (AH b3-4)

C. Physiology of Wool and Fiber

1. Skin follicle development in Angora goats. A study was made at Beltsville on skin samples taken from Angora goats from Texas and South Africa. There were 6 to 10 times as many secondary as primary follicles. Irrespective of age, Angora goats carried a considerable number of resting fibers in the primary follicles during the colder months of the year. In young goats, up to the third year, the secondary follicles show this to a much lesser extent. Medullation is usually confined to the primary follicles. Non-medullated fibers are more common in the finer, more uniform fleeces and tend to be associated with the ringlet type of Angora lock. (AH b5-1, 5)

2. Skin transplants in lamb fetuses. The Sheep and Fur Animal Research Branch is cooperating with the Department of Defense and Johns Hopkins University on studies of the response of the fetal lamb to antigenic stimuli. These investigations offer the opportunity to examine the growth of wool in transplants of the skin made from the region of the thigh to the fetal side. The transplants were rotated 180°. Thus, differences in length of wool, as well as direction of fiber growth, were used as conspicuous labels. Skin homografts made before the 75th day of gestation survive; those after the 75th day are rejected. The fact that fetal lamb will reject skin homografts is recognized as a specific immunologic response. (AH b5-1)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Physiology of Reproduction

Foote, W. C. and Hulet, C. V. 1965. Ram fertility. Farm and Home Science, Utah State University, March. pp. 20-21. (AH b1-7)

Hulet, C. V., Blackwell, R. L. and Ercanbrack, S. K. 1964. Observations on sexually inhibited rams. J. Anim. Sci. 23(4): 1095-1098. (AH b1-7)

Hulet, C. V., Foote, W. C. and Blackwell, R. L. 1965. Relationship of semen quality and fertility in the ram to fecundity in the ewe. J. Reprod. Fertil. 9(3): 311-315. (AH b1-7)

Hulet, C. V. and Foote, W. C. 1964. Semen testing and ram fertility. National Wool Grower 54(10): 14-16. (AH b1-7)

Lindahl, Ivan L. and Dwyer, E. W. 1964. Fetal electrocardiography experiments being conducted in Maryland research. Dairy Goat Journal 42(12): 3. (AH b3-12)

AREA NO. 15. SHEEP AND GOATS - NUTRITION AND MANAGEMENT

Problem. The cost of feed is the largest single expense in the production of lamb meat and wool. Information that would increase the efficiency of feed utilization, reduce feed costs, and increase productivity through better feeding practices would help the sheep producer meet the cost-price squeeze. Such information will come from basic studies of the development and function of the rumen, together with an understanding of how nutrients are metabolized in the animal. Such an understanding will enable sheep producers to modify and supplement rations in ways that will result in maximum production of desirable meat and wool. Much of the success or failure of sheep enterprises depends on production practices. Producers need better methods of animal management for the reduction of lamb mortality and disease and parasite losses, also procedures for handling ewes during breeding, gestation and lactation, as well as other labor-saving procedures and devices for the routine handling of sheep.

USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by biochemists, nutritionists, and animal husbandmen, involving basic nutrition and ruminant physiology studies, as well as application of known and new principles, in the development of better and more economic feeding practices of farm and range sheep. Basic studies on physiology and feeding practices and known and new principles in a number of fields are applied to the development of more productive management practices for farm and range sheep. These programs are carried on at Beltsville, Maryland; Dubois, Idaho; and College Station, Texas, in cooperation with other Divisions of ARS, and in formal and informal cooperation with State Agricultural Experiment Stations of Delaware, Idaho, Maryland, Montana, Oklahoma, Texas, and Utah.

The Federal scientific effort devoted to research in this area totals 3.0 professional man-years. Of this number, 1.1 are devoted to digestion and metabolism, 0.5 to forage evaluation and utilization, 1.0 to range and pasture management, and 0.4 to management practices, equipment, and facilities.

There are four grants involving Public Law 480 funds in foreign countries involving research on nutrition and management of sheep and goats. Two are with the Hebrew University of Jerusalem, and provide for (1) studies on the utilization of different kinds of protein feeds by ruminants at Rehovot, Israel, and supported for four years (1965-68) by \$89,927 equivalent in Israeli pounds, and (2) studies of the carbohydrate and fat economy of lactating sheep with particular reference to ketosis at the Hadassah Medical School and supported for three years (1965-68) by \$57,960 equivalent in Israeli pounds.

A project on the effects of feeding and management on white muscle disease in lambs at the Ankara University, Ankara, Turkey, is supported for five years (1963-68) by \$9,333 equivalent in Turkish lire.

A project was initiated with the Balwant Rajput College, Agra, Uttar Pradesh, India, involving investigations on milk and meat potentialities of Indian goats. The project is supported for five years (1965-70) by \$100,487 equivalent in Indian rupees.

PROGRAM OF STATE EXPERIMENT STATIONS

Basic studies of the function of the rumen, including the function of rumen microorganisms and the metabolism of products produced by rumen microbial activity, are being conducted. (Additional investigations of rumen function appear in problem area #1.) The effect of various mineral, hormonal, or antibiotic supplements upon ration digestibility and animal response are also under study.

Investigations are concerned with increasing the efficiency of sheep production through the use of concentrates at specific times in the growth of lambs (creep feeding), by formulating suitable rations for fattening lambs, and by devising economical rations for maintaining breeding ewes. The use of high-moisture corn and of the increased energy and protein available in the newly developed higher oil and higher protein corn are being studied.

Forage utilization studies include: (1) the influence of trace mineral supplementation, (2) the effect of grazing system upon forage quality and degree of utilization, and (3) forage digestion in the rumen.

The quantitative requirements for and the metabolism and interrelations of various minerals, proteins, and vitamins are being evaluated. The use of hormone, antibiotic, enzyme or other feed additives in improving growth and feed efficiency is a very active area of study. The relation of nutrition to animal disorders such as "stiff lamb disease," nitrate poisoning and trace mineral deficiencies is receiving attention. The effect of prenatal nutrition upon prenatal and postnatal development of the young is also under study.

Management studies underway include: (1) early weaning vs. conventional weaning, (2) creep feeding, (3) concentrate supplements for wintering ewes, (4) cleaning corn fields with sheep, (5) the production efficiency of different weights of feeder lambs and of wether sheep for wool and mutton production, (6) management effects upon range-land and grazing animals, (7) scales for chur's sorting, and (8) self feeders.

The State stations have 40.0 professional man-years devoted to this area.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Digestion and Metabolism

1. Metabolic disorders. Sodium and potassium carbonate, potassium bicarbonate and potassium and ammonium chlorides all reduced the incidence of urinary calculi in studies with wether lambs at College Station, Texas. However, sodium chloride, sodium bicarbonate and dipotassium and disodium phosphates either did not affect or else increased the incidence. Potassium bicarbonate afforded the best protection while potassium and sodium carbonates, and potassium chloride were about equally effective in reducing calculi formation. The critical level for protection lies between 1/4 and 1/8 oz. ammonium chloride per head daily.

At the Colby, Kansas Branch Experiment Station, when sorghum grain and alfalfa hay were fed free choice as a creep to milk-fed wether lambs, 12.5% of the lambs developed calculi. On the same diet with ammonium chloride added to the grain, only one lamb out of 37 developed a mild case of calculi. One case of calculi developed in 30 wethers on a mixed diet of 65% ground sorghum grain and 35% alfalfa hay. When the level of hay was increased to 55%, no calculi problems were observed. (AH b2-1)

Studies have been continued at Ankara, Turkey, on white muscle disease of lambs. Results of serum glutamic oxaloacetic transaminase (SGOT) determinations on 42 healthy lambs revealed 87 ± 3.5 units/ml. of SGOT (as microgram pyruvate) compared with 1132 ± 62 unit/ml. of SGOT of 47 lambs affected with white muscle disease. (A22-AH-2- Turkey)

2. Feeding practices and procedures. Studies on depraved appetite of sheep receiving limited amounts of pellets have been continued at Beltsville. The addition of 0.5% of sodium bicarbonate to the drinking water appeared to restrict the development of depraved appetites of sheep receiving limited amounts of pellets, but did not reverse the symptoms once they had become well established.

Studies were conducted at the University of Delaware comparing the response of sheep to alfalfa hay wafers made from flail chopped hay, from coarsely ground hay, and from finely ground hay with chopped and ground alfalfa hay. Wafers were preferred over chopped hay, and both over fines, when offered in a three-way simultaneous choice. Increased density and smaller particle size of the hay were related with higher levels of voluntary consumption. Changing of the physical characteristics of the hay diets without obvious changes in their chemical composition was responsible for an improvement in the nutritive value of the diets by 18%. Comparative responses of sheep and horses to different physical forms of alfalfa hay also were studied. The nutritive value indices for pellets, wafers, and loose hay were 45, 30, and 32, respectively, when fed to sheep, compared with 57, 59, and 44 when fed to horses. The results indicate that the physical form of feeds affects their nutritive value for horses as well as ruminants. (AH b2-5)

Experimental work on the measurement and characterization of metabolic fecal nitrogen of sheep on roughage diets have been continued at Beltsville. At a low, constant intake of nitrogen the effect of variable daily dry matter intake on fecal nitrogen excretion was direct and linear. At a higher, constant nitrogen intake (150% of the lower level) the effect also was direct and linear but, the estimate of MFN was about twice as great as at the lower level and the estimate of true nitrogen digestibility was absurdly high. These results indicate that either true nitrogen digestibility, or MFN, or both are complex functions of both dry matter and crude protein consumption and that chemical, as well as statistical means, are required to separate them.

In Beltsville studies urinary allantoin excretion by yearling crossbred wethers was increased linearly upon supplementation of either of two adequate basal diets with three increments of a highly purified, purine free wood cellulose. The supplementary cellulose was apparently digested and a higher reproduction rate of the rumen microbiota occurred. In the course of this reproduction, greater amounts of dietary nitrogen were synthesized into microbial cellular material, including purine containing compounds, and these in turn were digested and absorbed in the lower gut. These results indicate that the extent of microbial incorporation of dietary nitrogen into their own cellular constituents depends on the extent of microbial utilization of non-protein dietary constituents as well as previously established differences in utilization of various dietary protein sources.

Two series of metabolism experiments were conducted at Beltsville to study the effect of level of dry matter consumption and source of dietary phosphorus (P) on the phosphorus balance of yearling wethers. Dietary P was either provided by alfalfa hay or USP grade KH_2PO_4 . Urinary P was unaffected by treatment. Level of dry matter consumption or fecal dry matter excretion had no effect on fecal P excretion. Therefore, metabolic fecal P apparently is not influenced by the same variables as metabolic fecal nitrogen. There was no apparent difference in the utilization of the P from alfalfa and from KH_2PO_4 . These experiments also indicated that the minimum P requirement for equilibrium which has been stated to be 2.0 gram/day/100 pound of live-weight may be slightly low. (AH b2-7)

Feedlot performance of lambs weaned at 90 days of age and assigned to five different self-fed levels of roughage (chopped alfalfa) to concentrate (barley) in a completely pelleted diet was determined in a 52-day feeding period at Dubois, Idaho. The ratio of roughage to concentrate fed was 100-0 (1), 87.5-12.5 (2), 75-25 (3), 62.5-37.5 (4), and 50-50 (5). Feed cost per pound of gain was 11, 14, 12, 13, and 14 cents for lots 1 to 5, respectively. Carcass grade in lots 1 and 5 was high good, and low choice in lots 2, 3 and 4. After considering feed cost per pound of gain in transit shrink to market, carcass yield, and grade, lots 3 and 4 gave the greatest net income per lamb.

The relationships between feed efficiency of 48 Rambouillet ram lambs during the last half of an 84-day test on efficiency of gain, and their digestive abilities using data from four conventional digestion trials, were studied at Dubois, Idaho. There were highly significant correlations between feed efficiency and dry matter digestibility in two trials (-.68 and -.70). The more efficient animals digested the diet more completely. The same relationship existed between feed efficiency and digestible gross energy, but was significant only in one trial (-.66). Dry matter intake was significantly related to dry matter digestibility in two trials (.53 and .55). (AH b3-9, AH b1-13)

Trials at the New Mexico Agricultural Experiment Station on lambs from Fort Wingate showed that fattening lambs fed high energy diets gave excellent gain and feed efficiency. The salt requirements were dependent on the energy level fed. Terramycin did not have any beneficial effects on gain or feed efficiency. Ram lambs gained faster than wether lambs. There was no significant difference between two breeding groups in gain or feed efficiency. (AH b1-10, 11, 12)

Efficiency of utilization of dietary protein from toasted soybean meal was compared with that from alfalfa hay for growing Awassi rams at the Hebrew University of Jerusalem, Rehovot, Israel. Dietary energy, other than that from the protein sources, was supplied by cottonseed hulls. "True" and apparent digestibility of nitrogen was not significantly different but nitrogen retention was appreciably greater from the alfalfa crude protein. Peak rumen ammonia level was not affected by protein source. Alpha-amino nitrogen concentration of rumen fluid was considerably greater, and blood urea level was considerably less, on the alfalfa protein. Thus, the greater efficiency of alfalfa N utilization was apparently associated with its greater synthetic utilization in the rumen and its lesser wastage as urea.

The effect of two levels of dietary protein on the concentration of liver arginase and xanthine oxidase activities was studied in mature sheep. In contrast to published work in the rat, arginase activity was unaffected by level of dietary protein. The sheep liver may contain, even at low protein levels, sufficient arginase activity to metabolize large amounts of ammonia. Xanthine oxidase activity was greater at the higher level of protein, but the effect on its activity appeared to be considerably less than in the rat. (A10-AH-8-Israel)

3. Studies on nutritive requirements of sheep. The maintenance requirements of wethers kept under ordinary barn conditions were studied at Beltsville. Fifteen crossbred wethers, 12 to 14 months of age at the start of the experiment, were used. Criterion of maintenance was constancy of live weight, corrected for wool growth, at constant feed intake. Mean liveweight increase from 1964 to 1965 (347 days) was 1.77 ± 1.07 lb. Maintenance requirements were 22.6 grams digestible dry matter/day/kilo of weight to the 0.75 power. (AH b2-7)

Nutritive requirements of pregnant ewes were studied at Dubois, Idaho. One group of ewes was fed alfalfa hay pellets at the rate of 3.5 lbs./head/day, 7 and 8 weeks before lambing, and 4.7 lbs./head/day for the remaining 6 weeks before lambing (100 % level). This group was compared with groups fed 95, 90, and 85 % of the NRC recommendations, respectively. Body weight gains of the ewes ranged from 25 (100% level) to 19 pounds (85% level). Average gross fleece weights were 9.7, 9.6, 9.4, and 9.0 pounds, respectively. Lamb birth weights ranged from 11.2 (95%) to 10.8 (85%). Weaning weights of lambs were 82, 80, 82, and 79 pounds, and pounds of lamb weaned of ewes lambing was 105, 112, 107, and 103, respectively.

At Dubois, Idaho, lactating ewes self-fed alfalfa pellets and consuming 6.1 lbs./head/day were compared with ewes self-fed in feeders elevated 36" from the ground and consuming 6.7 lbs./head/day and with another lot of ewes hand-fed 6.0 lbs. Results show no real differences in lamb gains for feeding lactating ewes at the higher levels but ewe weight losses during this lactation period were 6 lbs., 14 lbs., and 21 lbs., respectively. (AH b2-9)

B. Forage Evaluation and Utilization

1. Forage evaluation. Relationship of cutting date to the nutritive value of three different varieties of orchardgrass hays was studied at the University of Delaware, using 70 sheep and 42 rabbits. Sheep appeared to prefer the variety containing the highest crude protein. Voluntary consumption by rabbits did not differ between varieties or cutting dates. Consumption by sheep was higher for the more digestible hays ($r=0.71$). Digestion coefficients for rabbits were closely related to those of sheep; 0.81, 0.86, and 0.93 for digestibilities of dry matter, energy and protein, respectively. Digestion coefficients for rabbits predicted those of sheep better than date of cut, or hay constituents. Date of cut predicted voluntary consumption by sheep better than the other criteria. (AH b2-7)

2. Forage intake by range sheep. Forage intake studies by range sheep were continued at Dubois, Idaho. The lignin ratio and total feces collection techniques were used to estimate the intake and digestibility of forage on high mountain summer range. Two methods of determining lignin were compared in analyzing the esophageal and feces samples. Because of greater variation with the "acid-detergent lignin" method, more fistula samples were required per animal to determine lignin content of the diet by this method than by the 72% H_2SO_4 method. (AH b3-9)

C. Range and Pasture Management

Effects of grazing sagebrush-grass range during summer. The effects of summer grazing sagebrush-grass ranges of the Upper Snake River Plains in Idaho which are normally grazed in the spring and fall only, are being investigated. Lambs were weaned at about 90 days of age and placed into feedlots while the ewes were placed on sagebrush-grass range. From 1960 to 1964

two intensities of summer grazing were used. Stocking rates were 24-35 and 35-45 sheep days per acre. Body weight losses of the ewes during the summer fluctuated more with years than with grazing intensities. Forage preferences of sheep on sagebrush-grass range during the summer shows that Indiangrass (Oryzopsis hymenoides) and needle-and-thread (Stipa comata) have consistently been the most preferred herbage species. The moderate (50%) use of downy rabbitbrush (Chrysothamnus viscidiflorus) and broom snakeweed (Gutierrezia sarothrae) in the heavily-grazed pastures compared to slight (10%) use of these species in the lightly-grazed pastures was very different in 1964. Threetip sagebrush (Artemisia tripartita) was rarely grazed from July 7 to September 15. (AH b3-1)

D. Management Practices, Equipment and Facilities

1. Performance of lambs weaned at 30-45 days of age. Twenty-eight Rambouillet X Dorset wether lambs were studied at Fort Reno, Oklahoma, in cooperation with the Oklahoma Agricultural Experiment Station. The early weaned lambs lost weight during the first eight days. At 142 days the early weaned lambs averaged 83 pounds compared to 95 pounds for the late weaned lambs. (AH b3-7)

2. Effect of testosterone-estradiol implants on gains, feed efficiency and carcass traits of lambs. Trials at the New Mexico Agricultural Experiment Station on lambs from Fort Wingate showed that lambs make better gains and require less feed per pound of gain until slaughter if they remain on essentially the same ration during post weaning as they received in a ration before weaning. The results show that an implant of testosterone-estradiol benzoate will increase rate of gain, decrease feed required per pound gain, reduce internal and external fat, and still produce a high dressing lamb that will grade mid-choice. (AH b1-10, 11, 12)

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AREA NO. 16: SWINE--BREEDING

Problem. Improvements in the heredity of swine depend on the intensity and accuracy of selection practiced in choosing breeding animals and on the choice of a mating system that maximizes the rate of genetic improvement. Crossbreeding swine for the production of market animals has so proved its value that over 90% of the pigs marketed in the United States are currently some kind of crossbreds. Research in swine breeding thus is faced with the dual challenge of developing foundation seed stock populations that yield maximum improvement for commercial production and also devising methods that fully utilize the genetic potential of available seed stocks for further increases from heterosis and hybrid vigor generally shown by crossbred pigs. It is essential that experimental work continue the development of genetic facts and practical methods that breeders can use to develop better and more efficient seed stock strains. Particular effort is needed on effective genetic means for efficient production of pork with more lean and less fat without sacrificing gains in other production traits.

USDA AND COOPERATIVE PROGRAM

This is a continuing program of basic and applied research conducted by geneticists and animal husbandmen to elucidate genetic principles and develop effective breeding systems that will result in further increases in the efficiency of swine with respect to productivity and carcass value. This is a coordinated research effort involving the USDA and several State agricultural experiment stations. Research is in progress at Beltsville, Maryland, cooperatively with the Montana Agricultural Experiment Station at Miles City, Montana, and at the Regional Swine Breeding Laboratory with headquarters at Ames, Iowa. The Regional Laboratory includes cooperative projects at State Agricultural Experiment Stations in Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Nebraska, North Carolina, Oklahoma, South Dakota, and Wisconsin. Investigations on genetic principles, selection, and breeding systems include work with swine and also with laboratory animals on important performance traits, their heritabilities, and their phenotypic and genetic correlations. The results of such studies provide the basis for emphasis given to different complex traits and the underlying factors in evaluating different systems for achieving genetic changes. Traits of major interest include productivity of dam, viability, growth rate, feed efficiency, carcass composition, and quality of meat.

Cooperative research with the Food and Drug Administration is in progress to investigate the response of "miniature" swine to further reduction in body size from selection, and their usefulness for toxological tests as well as basic studies in nutrition and genetics.

A grant with the College of Agriculture, Poznan, Poland, provides for investigations on red blood cell and serum antigens to establish the mode of

inheritance and relative frequencies of these antigens in certain breeds of swine. Its duration is for five years, 1962-1966, and involves PL-480 funds.

The Federal scientific effort in this area totals 7.4 professional man-years. Of this number, 5.2 are devoted to genetics and interrelations of performance traits and 2.2 to selection and breeding systems.

PROGRAM OF STATE EXPERIMENT STATIONS

Swine breeding research uses experiment station animals, herds of cooperating swine producers, and litters on tests in swine testing stations. Economic traits being considered include growth rate, feed deficiency, maternal ability, litter size, viability, and carcass yield and quality. Areas of investigation include estimation of genetic parameters, comparison of methods of selection and breeding systems, and evaluation of crossbreeding. In some instances, interrelationships of genetics and certain environmental factors such as housing, nutrition, and management are also being studied. Genetic parameters of interest include heritability (the degree which traits are influenced by genetic factors) of the above economic traits and the genetic and environmental relationships between these traits.

Much of the research on evaluation of breeding systems concerns the effectiveness of mass selection based on one or more of the economic traits. In addition, evaluation of recurrent selection to increase combining ability is being conducted. Meatiness of the carcass is one of the most important economic traits. Selection programs have recently been initiated to select for decreased backfat at market age. Crossbreeding in swine has been widely adopted by the industry. Research is in progress to determine the relative degrees of hybrid vigor resulting from crosses between specific breeds and strains and the value of selection within strains for the ability to combine well in crosses. Various systems of crossbreeding including crisscrossing, three-way crosses, and multiple breed crosses are being evaluated. Efforts are also under way to develop new breeds from crossbred foundations, and attempts are being made to maintain the superiority of crossbreds for every trait.

The North Central stations, in addition to North Carolina and Oklahoma, conduct swine breeding research in cooperation with the USDA through the Regional Swine Breeding Laboratory with headquarters at Ames, Iowa.

The total research effort on swine breeding research by the State agricultural experiment stations is 20.5 professional man-years.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Genetics and Interrelations of Performance Traits

Skeletal data obtained on selected and control line Duroc and Yorkshire pigs

showed similar trends with respect to breed and line differences as those reported last year. The number of thoracic and lumbar vertebrae averaged 20.5, 20.8, and 20.8 for tenth generation high-fat, low-fat, and control line Duroc pigs and 21.0, 21.2, and 21.8 for eighth generation high-fat, low-fat, and control line Yorkshire pigs. The corresponding averages for number of ribs were 14.4, 15.0, and 14.9 in the Duroc lines and 15.2, 15.2, and 15.5 in the Yorkshire lines. A total of 63 pigs were available for study with a range of from 6 to 12 pigs among lines. (AH al-12)

A study of sexual maturity with gilts being raised for breeding in a reciprocal recurrent selection program is now in its third year. The 137 gilts available for study this year were from the same four breed groups as those used during the first year. The two sets of crossbred gilts, designated by the symbols S-LB and S-BL, averaged about 10 pounds heavier and about 22 days younger in age at first estrus than the two sets of straightbred control gilts, C-LL and C-BB. Age at first estrus averaged 198, 202, 217, and 229 days for LB, BL, C-BB, and C-LL gilts, respectively. These results point in the same direction as those obtained for the same four groups in 1962 and, when considered with results obtained in 1963, confirm the conclusion that the selection practiced in the select strains S-LL and S-BB has had the effect of reducing age at first heat in both crossbred and straightbred gilts out of select strain females. (AH al-13)

Data collected over a three-year period on 477 gilts from Duroc and Yorkshire lines being selected on the basis of backfat thickness showed high-fat, low-fat, and control line Duroc gilts averaging 202, 201, and 195 days in age at first estrus, while high-fat, low-fat, and control line Yorkshire gilts averaged 211, 192, and 195 days, respectively. Over the same three years, about 3, 14, and 2% of the high-fat, low-fat, and control line Duroc gilts available for study failed to come in heat, compared with 19, 7, and 5% for high-fat, low-fat, and control line Yorkshire gilts. (AH al-12)

Data from 301 sows and 390 gilts showed statistically significant correlations of $-.16$, $-.12$, and $.12$ between gestation length and litter size at birth, litter weight at birth, and pig weight at birth. Positive phenotypic correlations of $.12$, $.19$, and $.16$ were obtained for age of gilt at breeding with litter size, litter weight, and average pig weight. The association of age of gilt with litter size and litter weight was found to be primarily a result of older gilts being heavier at breeding. Gestation gain in weight of gilt showed correlations of $-.14$ with litter size and $.16$ with average pig weight. The correlations of litter size with litter weight and individual pig weight were $.83$ and $-.55$, respectively. (AH al-8)

A study of 185 individually fed straightbred and crossbred Duroc and Yorkshire pigs showed phenotypic correlations of $.76$ between daily gain and daily feed consumption, $.24$ between daily gain and feed efficiency, and $-.54$ between daily feed consumption and feed efficiency. Estimates of the corresponding genetic correlations were $.90 \pm .07$, $.63 \pm .26$, and $.20 \pm .47$. The phenotypic and genetic correlations of percent lean cuts and carcass backfat with daily gain,

daily feed consumption, and feed efficiency suggested that selection for rate of gain would improve feed efficiency but would also be expected to increase backfat. Thus, both gain and backfat would have to be considered if improvement in these characters and in feed efficiency were desired. (AH al-10)

Backfat measurements taken at 125, 150, and 175 pounds on 208 boars and 233 gilts of a mildly inbred line of Poland China swine averaged .68, .76, and .87 inches for boars and .68, .78, and .88 for gilts. Phenotypic correlations between backfat probes at different weights ranged from .53 to .68 for boars and from .54 to .65 for gilts. Genetic correlations between probes at the same three weights ranged from .69 to .96, while the corresponding environmental correlations ranged from .16 to .43. Heritability estimates for backfat thickness were $.62 \pm .21$, $.42 \pm .17$, and $.35 \pm .16$ at 125, 150, and 175 pounds, respectively. (AH al-21)

A prediction equation was developed from data on 229 pigs for estimating pounds of lean cuts (Y) from line weight (W) and backfat probe (P). The equation $\hat{Y} = 12.9002 + .374 W - 10.30 P$ differs only slightly from one developed last year, and application of last year's equation to this year's data gave reasonably accurate predictions. (AH al-20)

One hundred and fourteen barrow-gilt littermate pairs from three lines of breeding were evaluated for differences in performance and carcass merit. Barrows gained .19 pound per day more and reached 200 pounds 12 days earlier. Gilt carcasses were .6 inch longer and had .10 inch less backfat, .44 square inch larger loin-eye area, and 4.1% higher yield of lean cuts. Feed efficiency records were essentially the same for both sexes. Differences between lines, sire groups, and sexes were significant for both marbling and firmness. Loins from barrows were firmer and had more marbling than loins from gilts. (AH al-8)

Data collected over a period of five generations of selection for low backfat thickness in two Poland China lines showed correlations for backfat probe with percent for lean cuts of $-.44$ in barrows and $-.54$ in gilts. Corresponding correlations with carcass backfat were $-.60$ and $-.37$, respectively. The heritability of backfat thickness was $.41 \pm .09$ from the intrasire regression of offspring on dam. The realized heritability based on the same data was slightly lower, i.e., $.32 \pm .09$. Other heritabilities derived from the intrasire regression of mean of offspring on dam were $.21 \pm .11$ for birth weight; $.17 \pm .07$ for 42-day weight; $.36 \pm .09$ for age at end of test; $.38 \pm .08$ for postweaning daily gain; and $.35 \pm .08$, $.35 \pm .08$, and $.27 \pm .08$ for scores for length, quality, and finish, respectively. Genetic correlations of backfat probes at three sites were $.67 \pm .11$ for shoulder-loin, $.82 \pm .06$ for shoulder-ham, and $.59 \pm .10$ for loin-ham. The genetic correlation between backfat thickness and daily gain was $.35 \pm .13$. (AH al-21)

Litter records collected from 1956 through 1964 on straightbred and crossbred daughters of 35 boars from two strains currently in a reciprocal recurrent selection program were used to obtain sire components of variance and

covariance. Traits studied were litter size and litter weight at birth, 21, and 56 days of age. Three variance components (v.c.) and two covariance components (c.c.) based on comparisons of CC with both SC and SS were available for each of the six traits. One-half of the 18 v.c. were negative, but most of the negative v.c. were smaller than the corresponding c.c. of the same sign. All but three of the 12 c.c. were negative. Due to negative v.c. obtained for some traits, genetic correlations could be calculated only for litter weight at 21 days from comparison of CC with SS and for litter weight at 56 days from comparison of CC with both SC and SS. These correlations were 1.18, -.38, and .61, respectively. The results obtained suggest that nonadditive gene effects may be important sources of variation in the traits studied. (AH al-13)

B. Selection and Breeding Systems

1. Selection for single traits. Selection responses in tenth generation high- and low-fat Duroc lines and eighth generation high- and low-fat Yorkshire lines were of about the same magnitude as in last year's pigs. Backfat thickness in tenth generation high-fat, low-fat, and control line Duroc pigs averaged 2.06, 1.04, and 1.46 inches, compared with 2.00, 1.18, and 1.52 inches in ninth generation pigs. Eighth generation high-fat, low-fat, and control line Yorkshire pigs averaged 1.47, .92, and 1.18 inches, compared with 1.46, .99, and 1.22 inches in seventh generation pigs. Based on selection responses expressed as deviations from nonselected controls, the realized heritability of backfat thickness at a liveweight of about 175 pounds now stands at .47 for both the high- and low-fat Duroc line and at .35 and .52 for the high- and low-fat Yorkshire lines. Heritabilities calculated from offspring-midparent regressions, using data adjusted for sex differences, date of birth, inbreeding of pig, and weaning weight of pig, had values of .44, .59, and .60 for the high-fat, low-fat, and control line Durocs and .49, .68, and .46 for the high-fat, low-fat, and control line Yorkshires. While backfat thickness does not appear to have reached a plateau in any of the selected lines, both the high- and low-fat Duroc lines have shown a rather marked decline in various components of fitness, with both of these lines now averaging about two pigs less in litter size at weaning than the control line. Conception rates of ninth generation gilts, based on percent farrowing, have also shown a rather marked decline (59%) in the low-fat Duroc line as compared with the high-fat (100%) and control line (88%) gilts. None of the Yorkshire lines, on the other hand, have given any cause for concern as regards their reproductive performance. (AH al-12)

A selection experiment involving a spring and fall replication of five generations of selection for low backfat thickness has been completed. Records on 1,828 animals by 67 sires and from 270 dams were available for study. Inbreeding increased to about 10.8% but its effects were not significant for most traits. Backfat thickness at a liveweight of 175 pounds decreased .25 inches in the spring line and .20 inches in the fall line. There was no adverse effect on reproductive performance, birth weight, 42-day weight,

age at end of test, daily weight gain, or feed efficiency as a result of the reduction in backfat. Ovulation rate and live embryo counts in samples of gilts slaughtered each generation were not altered with reduction of backfat, although leaner gilts tended to produce more ova. A realized heritability of $.32 \pm .09$ was obtained for backfat thickness. (AH al-21)

A new project has been initiated at one station in which selection for large and small litter size is being practiced in the Duroc and Yorkshire breeds. Litter size is measured by an average of (a) size of dam's first litter, and (b) number of normal appearing embryos in the dam's reproductive tract at 35 days of her second pregnancy. Number of pigs per litter at birth, number of corpora lutea, and number of normal appearing embryos averaged 10.2, 25.1, and 15.8 for Duroc foundation gilts and 11.7, 19.2, and 13.5 for Yorkshire foundation gilts. (AH al-9)

2. Selection for combining ability. Following the pattern established in 1957 for odd-numbered years, fifth cycle litters produced this year in a reciprocal recurrent selection program at Beltsville were the product of intrastrain matings among animals selected on the basis of their cross progeny performance in 1964. The inbreeding of the two strains being used in the project now averages 27% for the LL strain and 13% for the BB strain. Weaning and postweaning data obtained in last year's phase of the fifth cycle showed crossbred BL and LB litters exceeding control LL and control BB litters by 1.8 and 1.6 pigs or by 28 and 29% in litter size at weaning, by 52 and 92 pounds or by 25 and 44% in litter weight at weaning, and by .12 and .18 pounds or by 8 and 12% in daily gain from weaning to a final weight of about 220 pounds. These advantages for fifth cycle crossbred pigs are of about the same magnitude as those observed for fourth cycle crossbreds. (AH al-13)

In the Miles City project, data obtained in 1964 on 30 litters representing all possible crosses among the Montana No. 1 select, Yorkshire select, and Montana No. 1 control strains and 23 straightbred litters divided about equally among the three strains showed crossbred litters exceeding straightbred litters out of the same three kinds of dams by 2.0, 1.1, and .9 pigs or by 26, 9, and 8% in litter size at birth; by 1.5, .3, and 1.3 pigs or by 24, 3, and 19% in litter size at weaning; and by 66, 62, and 47 pounds or by 25, 15, and 17% in litter weight at weaning. Samples of pigs fed from each group under record-of-performance conditions showed advantages of 13 and 8% in daily gain for crossbred pigs out of Yorkshire select and Montana No. 1 control sows with practically no advantage for crossbred pigs out of Montana No. 1 select sows. (AH al-11)

Data collected at North Carolina from five Duroc and eight Yorkshire boars with both purebred and crossbred progeny were used to obtain preliminary estimates of the effectiveness of selection in purebred populations for achieving improvement in crossbred populations. The Duroc and Yorkshire boars had a mean of 31 and 39 purebred and 170 and 98 crossbred pigs, respectively. Genetic correlations between purebred and crossbred progeny means

were .22 and .72 for 154-day weight and .21 and > 1.00 for backfat for the Duroc and Yorkshire boars, respectively. Corresponding rank correlations were .08 and .16 for weight and .67 and .12 for backfat. In addition, the Duroc boars had a mean of 6 purebred and 28 crossbred daughters producing litters. The genetic correlations between purebred and crossbred performance were $-.74$ and < 1.00 for number farrowed and number raised, respectively. The corresponding rank correlations were $-.70$ and $-.70$. The results, especially for litter size, suggest that selection for purebred performance will be relatively ineffective for improving crossbreds.

3. Development and evaluation of inbred lines and crosses. A miniature herd of swine has been established at Beltsville, Maryland, by the Food and Drug Administration for toxicity studies and by the Animal Husbandry Research Division for research in swine genetics. Selection is primarily for a white skin and hair coat and reduced body size. The foundation herd was formed by purchasing 6 boars and 20 sows from the Hormel Institute, Austin, Minnesota, in 1963, and 1 boar and 3 sows from Hanford Laboratories, General Electric Company, Richland, Washington, a contractor for the U. S. Atomic Energy Commission, in 1964. The present herd consists of 8 boars and 40 breeding females. Thirty-seven litters farrowed in 1963 and 1964 averaged 8.0 pigs for litter at birth with 5% classed stillborn. Litter size at 21 and 56 days of age averaged 5.6 pigs (70% survival) and 5.4 pigs (68% survival), respectively. Weights of Hormel, Hanford, and first-cross Hormel x Hanford pigs averaged 1.62, 1.68, and 1.87 pounds at birth; 6.4, 6.2, and 6.4 pounds at 21 days of age; and 17.4, 17.4, and 21.8 pounds at 56 days of age. Pig weights of the three groups were similar at 98 and at 140 days of age. At 9 months of age boars and gilts averaged about 110 pounds, while at 30 months the average weight of boars and open sows was about 66 pounds.

4. Gene pools. A gene pool, comprised of 14 older breeds, has now been completed. A gene pool of new breeds is still being formed. The performance of the gene pool of new breeds has been quite satisfactory with respect to litter size, individual growth rate, and backfat thickness. Plans are under way to have Montana No. 1 and Maryland No. 1 stock available for producing 1966 litters. (AH al-20)

5. Breed evaluation. An effort to improve meatiness in five breeds has resulted in considerable success at one station. Carcass data from 1,377 pigs indicated that (a) the Hampshire excelled in percent ham and loin, area of loin eye, and backfat thickness; (b) the Poland was noticeably better in meatiness but was shorter and had more backfat than the Hampshire; and (c) the Landrace and Yorkshire were quite similar in all measurements, both being superior to the Duroc in percent ham and loin and area of loin eye. Spring and fall pigs differed little in length or backfat, but the fall pigs were superior by .7% in ham and loin and by .28 square inch in loin-eye area. Over a three-year period, little change in carcass length or carcass backfat has occurred, but ham and loin have increased 1.8% and loin-eye area .43 square inch. (AH al-22)

6. Performance and progeny testing. Five central testing stations are now operating in Iowa. A production-tested barrow contest in which a total of \$1,000 in prizes is offered for animals which excel in growth rate and meatiness has been initiated. Approximately 200 barrows will be tested at the Iowa Swine Testing Station at Ames prior to display at the Iowa State Fair in August 1965.

A full scale effort has been initiated at one of the Iowa stations to adopt ultrasonic techniques to field evaluations of meatiness. Approximately 700 barrows from experimental herds will be evaluated with the Bronson Model 12. If a satisfactory technique can be devised, local swine improvement associations plan to purchase additional instruments and carry the program to the field. The university staff will assist in training personnel and in keeping and interpreting records. (AH al-22)

PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS

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AREA NO. 17: SWINE--PHYSIOLOGY

Problem. Increased efficiency in the production of pork is dependent on the elucidation of the basic mechanisms underlying physiology of growth, reproduction, genetics, and environmental adaptation. Since artificial insemination in swine has a great potential, particular emphasis is needed on basic studies in physiology of reproduction related to the development of an effective and practical program.

New genetic aids for improvement of swine require additional understanding of the physiological processes, particularly those involved in the growth and production of high quality lean meat.

USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by physiologists, biochemists, and animal husbandmen on basic and applied problems in the physiology of reproduction, artificial insemination, and the physiology of growth and development, particularly with respect to the mechanisms involved in deposition of fat, muscular development, and inborn metabolic differences. The research effort at Beltsville, Maryland, involves (1) the development of basic knowledge on swine physiology using animals with contrasting genetic differences, and (2) studies on reproductive physiology.

Cooperative studies at Missouri and Nebraska, which are part of the Regional Swine Breeding Laboratory program, are also included.

The Federal scientific effort on research in this area totals 2.4 man-years. Of this number, 1.2 is on physiology of reproduction and 1.2 on physiology of growth and development.

PROGRAM OF STATE EXPERIMENT STATIONS

Much of the current program of research in this area is based on the thesis that increased reproductive efficiency in swine is dependent primarily upon an understanding of the nutritional and physiological influences on variability of ovulation rate and embryonic survival. Fundamental studies are under way designed to yield information on endocrine events occurring at the time of ovulation, and physiology of the uterine tract conducive to maximum embryonal survival. The effect of the level of nutrition at various stages of growth and development on ovulation rate and embryonal survival is also being studied.

Artificial insemination shows considerable promise in swine as it has in other species. Problems peculiar to swine must be solved, however, before the technique has practical application. Swine spermatozoa are relatively short-lived in vitro, and the volume and concentration of the ejaculate are

quite variable. These and other problems under study include the effects of the accessory glands on semen quality, and yield and composition of sow's milk and the effect of lactation stress on subsequent reproduction. The NCR-26 regional project is concerned with artificial insemination of swine.

Stress factors under study include high and low ambient temperature, optimum temperature and humidity at different stages of development, and interrelationships of environmental temperature with nutrition and environment. The effects of cooling of males and females on conception rate and prolificacy are also being investigated.

Additional studies in this area, including design of housing and equipment, are being conducted in cooperation with Agricultural Engineering including a new regional project, NC-72, Swine Housing Environment.

State stations are investigating the influence of inbreeding and crossbreeding on physiological mechanisms affecting growth and fertility. One station is studying differences in carcass characteristics between barrows and gilts with particular reference to time and rate of development, and the influence of feeding low levels of hormones on sex-influenced growth pattern. Extensive basic research is concerned with the nutrition and physiology of the developing swine fetus. Changes in total serum protein and serum protein electrophoretic patterns during fetal development are being investigated and histological changes of the gastrointestinal tract as they occur during development of the fetus are being characterized.

The total State scientific effort devoted to swine physiology research is 18.0 professional man-years. An additional 7.5 professional man-years pertain to Area 1 (Animal Biology) and are reported therein.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Physiology of Reproduction

1. Synchronization of estrus. The first work at Beltsville, Maryland, demonstrating effective symchronization of estrus in gilts with 1- α -methylallylthiocarbamoyl-2-methylthiocarbamoylhydrazine (ICI 33,828) (MATCH) is summarized in last year's report. Eighty-seven gilts and sows have been used in two separate experiments. This work included studies of the physiological action of MATCH, effective dosage level, duration of the feeding period, stage of the cycle when treatment was initiated, ovulation rate, fertilization rate, embryo survival, and litter size.

Feeding of the compound on the basis of weight was not essential. The addition of 100 mg. of MATCH to the daily ration of the gilt or sow resulted in good synchronization of estrus. All gilts returned to estrus 4 to 8 days post treatment (93% on either day 5, 6, or 7). All sows treated at the optimum level returned to estrus 5 to 11 days after treatment. No adverse effect on the reproductive performance of sows or gilts has been noted.

Overall conception rate of the treated animals was 74.3% compared to 69% for the controls. Average litter size was 8.3 and 9.0 for treated and controls, respectively.

Further research and field investigations of MATCH are needed. It is an effective research tool and provides for the first time the possibility of a practical way for extensive use of artificial insemination in swine.

(AH al-19)

2. Factors influencing estrus and fertility. The reproductive response of the more mature sow to different levels of energy intake before and after breeding was studied in 44 sows. Flushing for approximately two weeks prior to breeding significantly increased average daily gain (1.41 vs. 1.11) but failed to improve ovulation rate (15.0 vs. 16.0) for flushed and nonflushed sows, respectively. Average daily gain was significantly increased (1.8 vs. .93) by continuing sows on the flush ration after breeding. Sows fed the high energy ration before and after breeding had a lower conception rate (76 vs. 100%) and there was some reduction in embryo survival in those sows pregnant at slaughter (59.4 vs. 67.3%). These results suggest that little benefit may be expected from flushing sows and flushing may actually be more harmful than beneficial if extended into early gestation. (AH al-20)

3. Anatomy of the reproductive tract. The angioarchitecture of the internal genitalia of 26 female swine showed the arteries anastomose freely and allow fluid injected into any one artery to flow into other arteries of the genitalia. A similar anastomosis exists in the veins. The study revealed that the so-called utero-ovarian artery does not send a branch to the uterine horn, thus a more descriptive name would be ovarian artery. Also, the artery originating from the umbilical artery might be designated as the uterine instead of the middle uterine artery, as it supplies the entire uterine horn. No cranial uterine artery is found in the pig. The uterine branch of the urogenital artery supplies the cervix and uterine body. These and other findings of this study provide a better understanding and establish a sound basis for further work on the vascular system and its role concerning uterine-ovarian relationship. (AH al-21)

4. Location and cleavage stages of swine ova. Fifty-five gilts and sows representing three breeds were used in a study of ova transport. Swine ova were found to be transported through the oviduct at a faster rate than has been reported for sheep, cattle, and many other mammalian species. Ova passed through the first half of the oviduct very rapidly and were found in the third quarter (which contains the ampullary-isthmic junction) 60 to 75 hours after onset of estrus. The ova then passed through the fourth quarter of the oviduct and entered the uterus between 66 and 90 hours after onset of estrus. This knowledge should facilitate in vivo recovery of uterine ova in developing transfer techniques. (AH al-21)

B. Physiology of Growth and Development

1. Physiological differences under genetic control. Biochemical and hematological measurements were obtained from 56 Durocs and Yorkshires in lines selected for 10 and 8 generations, respectively, on the basis of backfat thickness. Mean difference in backfat thickness between high-fat and low-fat lines was .93 inch for Durocs and .44 inch for Yorkshires. The measurements taken were number of red and white blood cells, hemoglobin, plasma protein, blood glucose, and cholesterol. Red blood cell counts of the control and low line Durocs were higher than the high line Durocs ($P < .01$). Total cholesterol values of the high Duroc line differed significantly from the low Durocs ($P < .05$). An increasing linear trend in total cholesterol was observed from the low to the high backfat lines in the Durocs. These data indicate that physiological differences have been introduced by selection. Further studies using biochemical measurements are needed to examine the possibility of predicting the carcass composition of the market hog at an early age. (AH 41-19)

2. Gastrectomized pigs. In cooperative exploratory work with the National Institutes of Health, gastrectomized swine were used to study the influence of the absence of the stomach on degenerative changes in the central nervous system similar to those noted in human patients afflicted with amyotrophic lateral sclerosis. Five pigs were subjected to total gastrectomy and showed transitory clinical symptoms (hypersensitivity, spastic paralysis, unsteady gait) which suggested involvement of the central nervous system. Histological examinations of tissue from three animals have been completed and these showed no apparent differences from controls. All gastrectomized animals developed progressive hypochromic and microcytic anemia. Growth rate of the gastrectomized animals was approximately one-half that of the controls. One pig partially gastrectomized (cardiac and fundus region removed) grew at approximately the same rate as the controls and did not develop anemia. This suggests that the gastric mucosa of the pyloric region of the stomach may secrete a factor (similar to B₁₂ intrinsic factor) which combines with iron and renders it "absorbable" by the mucosa of the gastrointestinal tract. (AH 41-19)

3. Lactation in the sow. Six lactating crossbred sows and their litters (adjusted to six pigs each) were used to study the effect of MATCH on lactation. Milk yield was computed by weighing the pigs before and after each of three equally spaced nursings in 12 hours. The pigs were with the sow for the remainder of the 24-hour period. In a 14-day treatment period the sows showed either a partial or complete block to milk letdown. The block to milk letdown could be overcome by intravenous doses of oxytocin. These data suggest that MATCH exerts a pituitary hypothalamic block and that its principal effect in the sow was inhibition of the milk ejection reflex. Further, it points out the problem that would arise if one attempted to synchronize estrus in lactating sows that were nursing piglets. (AH 41-19)

4. Anatomy and secretion rate of the thyroid in swine. Tissues ventral to the porcine thyroid were dissected to establish the relationship of these structures to the thyroid gland. Arterial supply and venous drainage of the gland were also determined. Determinations of the release rate of I^{131} from the throid of swine that received daily injections of L-thyroxine were made on 213 animals from the Poland China, Hampshire, Yorkshire, and Duroc breeds. A total of 257 observations are involved. The mean daily thyroid secretion rate for all animals was found to be .29 mg. L-thyroxine per 100 pounds of body weight. Males and females did not differ significantly. The secretion rates were significantly higher in the Yorkshire breed at higher temperatures and in the Poland China breed at lower temperatures. Average daily secretion rates of L-thyroxine per 100 pounds of body weight were higher in pigs 2 to 8 months of age (.41 mg.) than in pigs 10 to 14 months (.19 mg.). Significant positive correlations were found within sex and within breed between daily thyroid secretion rate and daily rate of gain of Poland China males and Yorkshire pigs. No significant association between thyroid activity and gaining ability was observed in Poland China females or Hampshire pigs. (AH al-21)

PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS

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AREA NO. 18: SWINE--NUTRITION AND MANAGEMENT

Problem. The changing demands of the consumer for pork with a high proportion of lean are requiring major changes in the nutrition and management of swine. Furthermore, the use of materials other than lard has greatly reduced the demand for fat-type hogs. Along with the change in genetic makeup which must be made, basic facts concerning metabolic functions require investigation. Furthermore, the basic nutritional factors which influence growth and carcass composition need to be identified and evaluated. These require information on quantitative and qualitative requirements at various growth stages and the changes in requirements to adjust for altered levels of other nutrients or modified environment. To meet the competition of other foods, including other meats, the nutrition and management of swine must constantly be aimed at improvement of feed and labor efficiency. More recently the dependence on use of pesticides for protection of quality and quantity of the nation's food supply has created a difficult and sensitive problem. Although essential to maximum agricultural production, these chemicals must be used safely to prevent contamination of food or environment with harmful residues.

USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by biochemists, nutritionists, and animal husbandmen investigating basic and applied problems in swine production related to nutrition, metabolism, and management. Work is in progress at Beltsville, Maryland, and cooperatively with the Agricultural Engineering Research Division, as well as through informal collaborative agreements with the Food and Drug Administration and the Southern Utilization Research and Development Division. There is also a research contract with Purdue University. These studies contribute to the establishment of nutrient and mineral requirements and the relation of different components of the diet to each other; to the development of more efficient and economical rations; to the relation of genetic differences to dietary requirements; to the influence of management practices on total production, and more specifically on pesticide residues in pork products; and to the role swine may have as an experimental animal for the investigation of health and dietary problems in man.

The total Federal scientific effort in this area amounts to 4.6 professional man-years. Of this number, 1.0 is devoted to digestion and metabolism; 0.5 to concentrates, evaluation, and utilization; 1.0 to feeding methods; 1.0 to nutritional requirements; 0.6 to management practices, facilities, and equipment; and 0.5 to environmental stress on nutrient intake and performance.

PROGRAM OF STATE EXPERIMENT STATIONS

Swine nutrition research at the State stations is directed toward expanding

our knowledge on nutrient requirements for growth, gestation and lactation, nutrient interrelationships, and nutrient availability in swine feeds. This work is concerned with developing simplified baby pig starter rations; determining the amounts of amino acids, minerals, vitamins, and energy needed to properly supplement growing-finishing rations based on common dietary ingredients; the influence of protein and energy components of the diet on efficiency of gain and carcass composition; and the effects of level of total nutrient intake before and during the gestation period on ovulation and conception rate, litter size, prenatal mortality, and viability of offspring. New feed additives are being evaluated for growth promoting properties.

Fundamental studies under way are designed to yield information on nutrient absorption and metabolism and digestibility coefficients. The protein components of milk and colostrum are being determined. Techniques that utilize the changes of free amino acid content of the blood plasma as indicators of dietary amino acid deficiencies are being developed.

Various management practices during the growth, gestation, and lactation periods are being evaluated for ways to develop a more efficient and economical swine operation. Methods of restricted and interval feeding are being studied. Other aspects are concerned with space allowance, behavior, type of floor, zone cooling, age of weaning on subsequent performance, and the relative merits of pasture or drylot feeding.

The total State scientific effort devoted to swine nutrition and management is 67.0 professional man-years.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Digestion and Metabolism

The response to different levels of dietary energy by Duroc and Yorkshire lines selected over several generations for either maximum or minimum backfat was measured in two trials. This involved individual feeding trials and physical separation of carcasses from 128 pigs ranging in age from 90 to 400 days. The absolute weights of fat and lean up to 400 days of age were linear for all groups. Restricted energy intake up to 230 days of age reduced the accumulation of lean in low-fat lines by 23 and 20% for Yorkshires and Durocs, respectively. There was little or no reduction in the high-fat lines. The restricted energy intake resulted in a relatively uniform reduction in rate of fat accumulation ranging from 33 to 40% for all lines. The average ages at which pounds of fat exceeded pounds of lean in the carcass were as follows: high-fat Yorks restricted, low-fat Yorks normal, and low-fat Durocs restricted, 38, 36, and 35 weeks, respectively; low-fat Durocs normal, high-fat Durocs restricted, high-fat Yorks normal, and high-fat Durocs normal, 29, 23, 22, and 20 weeks of age, respectively. Low-fat restricted Yorks generally had more lean than fat in the carcass at all ages. Balance trials at 90 and 110 days of age showed that pigs in both York lines consistently retained more nitrogen per unit of retained energy

on the restricted diet than on the normal, while the Duroc lines were more variable in their response. The high-fat Duroc line continued to be the lowest in nitrogen retention (3.14 mg.N/kcal.). Low-fat lines in both breeds made the most rapid and efficient gains up to 230 days of age. Reduced energy intake slowed the rate of gain in all lines, ranging from about 15% in the low Yorks to 25% in the low Durocs. There was a 5% improvement in feed efficiency as a result of energy restriction in all lines except the low Durocs. Efficiency in this line was not affected by the reduction in energy intake. (AH a3-18)

B. Concentrates - Evaluation and Utilization

1. Nutritional quality of cottonseed meal. Further testing of cottonseed meal obtained by solvent extraction with a combination of acetone, hexane, and water supported previous experimental evidence of high nutritional value and extremely low toxicity. The cottonseed meal had been stored for approximately a year without refrigeration. It was compared with a fresh supply of soybean meal, each used as the sole protein concentrate and with a 50-50 combination of the two meals. In spite of the age of the mixed solvent cottonseed meal, it produced gains only slightly but not significantly inferior to those from the soybean meal. The cottonseed-soybean combination gave the same gains as soybean meal alone. (AH a3-19)

2. Detoxification of cottonseed meal. The addition of seven iron compounds to a toxic cottonseed meal diet which was fed to weanling male rats identified two grades of ferrous fumarate, ferric citrate, ferric ammonium citrate, and ferrous sulphate (at 2 g. fe./kg. of diet) as supporting normal growth without evidence of toxicity. Ferric oxide and ferrous oxalate were ineffective as detoxicants. Subsequent experiments with rats and swine suggest that iron compounds may vary slightly in effectiveness as detoxicants but do not otherwise improve protein quality and may decrease palatability of the diet. In another phase of the same experimental series, four lots of six pigs each were fed combinations of soybean meal and toxic cottonseed meal as protein concentrates. Lots which received ratios of soybean meal to toxic cottonseed meal of 100:00, 75:25, and 50:50, showed respective gains of 1.55, 1.70, and 1.60 pounds per day (not significantly different) without any toxic symptoms. However, when the ratio was 25:75, the diet was toxic to four of six pigs. These results indicate that blending soybean meal with toxic cottonseed meal can prevent toxicity and may improve protein quality of the diet. (AH a3-19)

C. Feeding Methods

First results of a test of reproductive performance of gilts which were group-fed three levels of feed intake throughout gestation were reported previously. Indications were that the intermediate allowance (4.5 lb./gilt daily) gave markedly superior performance to either the high level (6.0 lb./gilt daily) or the low level (3.0 lb./gilt daily) in terms of number of pigs weaned per litter. Much of the poor performance was attributed to

uneven feed intake consequent to group feeding. The more greedy gilts on the 6.0 pounds ration became too fat while the least aggressive gilts on the 3.0 pounds ration were quite thin. Under either condition initial litter size was sharply reduced.

For the second gestation period all sows were fed in individual feeding stalls and the three levels of feed were supplemented to provide essentially the same adequate level of vitamins and uniform feed intake by individuals on each prescribed allowance. As a result of these adjustments, weaning data from the fall 1964 farrowing by the same females and spring 1965 farrowing by the next generation of gilts fail to indicate significant differences in terms of initial litter size, weaned pigs per litter, or average weaned weight. The feed saving (over the 6.0 pounds ration) during the gestation period has been approximately 180 and 360 pounds for the 4.5 pounds and 3.0 pounds allowances, respectively. However, gilts from the two latter levels which were self-fed for a lactation period of 42 days ate approximately 50 pounds more feed than their littermates from the 6.0 pounds gestation level. This reduced the net saving to 130 pounds and 310 pounds, respectively. (AH a2-5)

D. Nutritional Requirements - Trace Mineral Requirements and Interrelationships

1. Effects of EDTA on zinc utilization at various levels of calcium and phosphorus. A preliminary small scale test with swine indicated that the chelating agent, ethylene diamine tetra acetic acid (EDTA), increased absorption of dietary zinc (Zn) in the presence of 1.2% calcium (Ca) and .8% phosphorus (P).

Three subsequent experiments with weanling male rats measured the effect of .1% of EDTA added to diets which varied in content of Ca, P, and Zn. Data were obtained on rate of growth, feed efficiency, Zn excretion (fecal and urinary), and Zn storage in hair, bone, and liver. Although the addition of EDTA increased growth rate on all Zn levels studied (9 ppm, 19 ppm, and 38 ppm) and at all levels of Ca and P tested, maximum growth occurred with a balanced ratio of Ca and P and the medium (19 ppm) Zn level. While EDTA also markedly improved growth at the low (9 ppm) level of Zn, the growth rate did not approach the maximum. (AH a3-12)

2. Methods of preventing iron-deficiency anemia of baby pigs. Intramuscular injection of 1 ml. of iron-dextran containing 100 mg./ml. has been routinely given to pigs at birth and again at three weeks of age as a standard anemia preventive for a number of years. The following treatments were assigned to litters in rotation according to birth dates: (1) injectable iron-dextran, (2) a commercial pellet, (3) a commercial block, (4) a mixture of three parts clay to one part ferrous sulphate, and (5) three parts skim milk powder and one part ferrous lactate. Hematocrits taken at 7, 14, 21, and 28 days showed that all treatments afforded some protection, although there were a few exceptions where treatments failed

to respond to iron supplementation. Treatment 3, the commercial block, was least effective in maintaining hematocrit values at 7 days but all litter averages were at satisfactory levels at 21 and 28 days. Treatment 5, the milk powder-ferrous lactate combination, had a higher proportion of borderline readings than the other materials. (AH a3-12)

E. Management Practices, Facilities, and Equipment

1. Nonchemical methods for reducing pesticide residues. Three intensities of cleaning were evaluated as to efficacy of reducing internal parasites in pigs on concrete. Daily washing with a high pressure hose was compared with similar washing at 14-day intervals and with shovelling out excess manure three times weekly. Balanced lots of four pigs were randomly assigned to the three treatments. The treatments were replicated three times with pigs which had not been treated for removal of internal parasites while a fourth replicate had been wormed with a piperazine compound at the start of the experiment. Preliminary fecal samples revealed only light infestation of internal parasites, mainly ascarids. An examination of lungs, livers, and contents of small intestines at slaughter showed a trend toward reduced ascarid numbers with intensity of sanitation. None of the differences were significant although the reduction in adult ascarids was marked. Failure to show significant reductions in ascarids is attributed to the light initial infestation of the parasites. Growth was normal (1.58 lb. av. daily gain) and apparently not influenced by parasites.

2. Tissue residues in swine exposed to pesticides. Preliminary investigations were conducted through informal collaboration with the Pesticide Chemicals Research Branch of the Entomology Research Division. Techniques have been standardized for chemical applications to or on the animal and for biopsies of backfat to permit measurements concerning absorption, retention, and dissipation of residues. Pilot studies with lindane used as a spray for external parasites showed residues in samples of backfat removed by biopsy over a period of six months. Further tests with other swine revealed that lindane residue reached a peak at 4 to 7 days after treatment, and that 28 days after treatment the lindane residue persisted at levels of .1 to .3 ppm in the backfat.

PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS

Digestion and Metabolism

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AREA NO. 19. FUR ANIMAL HUSBANDRY

Problem. Fur animal investigations are needed to obtain fundamental information on methods of increasing the productivity of ranch-raised fur animals, including rabbits. Controlled research is needed on the development of superior lines, or possibly new breeds, for producing higher quality fur and better rabbit meat. The genetics of mutations of mink and foxes and the inheritance of factors for quality of fur and of meat in rabbits require continuous study. Feeding investigations are needed to determine nutritive requirement of various species and the most economical sources of feed to meet their requirements. Of special need is the finding of satisfactory substitutes for expensive raw meat. Low cost byproducts of the meat and fishing industries must be under constant study to develop practical diets. Successful husbandry of these animals requires extensive study of the peculiar characteristics of reproduction and their relation to productivity.

USDA AND COOPERATIVE PROGRAM

This is a continuing program and involves (1) genetic investigations of traits for use in improvement of rabbits, minks, martens, and foxes; (2) research on the reproductive performance of mink, including the effects of hormones and the process of lactation; (3) estimates of genetic parameters and maternal effects concerning economic traits in the production of fryer rabbits; (4) studies with regard to the priming process in fur bearing animals through investigations of the mechanisms involved in the growth of hair follicles; (5) research on the basic nutrient requirements and nutrient utilization by mink and the development of diets based on fish, meat and their byproducts for mink, fox, and marten; and (6) the relationship of nutrient factors and physical characteristics of the diet to rabbit production, including the study of various proteins.

The work is in progress at Beltsville, Maryland; Fontana, California; Ithaca, New York; and Petersburg, Alaska. Cooperation is maintained with Swarthmore College and State Experiment Stations of Alaska, California, New York, and Wisconsin. Close cooperation is maintained with the National Board of Fur Farm Organizations.

The Federal scientific effort devoted to the research in this area totals 5.0 professional man-years. Of this number 0.5 are devoted to fur animal breeding, 0.8 to fur animal physiology, and 3.7 to fur animal nutrition and management.

PROGRAM OF STATE EXPERIMENT STATIONS

Six State experiment stations, Alaska, California, Florida, Michigan, New York, and Oregon are conducting fur animal nutrition research, some of which is in cooperation with the U. S. Department of Agriculture. These studies are primarily concerned with establishment of basic nutrient requirements of rabbits and mink.

The value of antibiotics and antioxidants in mink diets is also being investigated. Consideration is given to development of low cost rations for mink including dry diets. The nature, cause, and control of fur abnormalities in mink are being studied. All fur animal breeding research is conducted in cooperation with the U. S. Department of Agriculture.

The total effort on fur animal husbandry at the State experiment stations is 7.5 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Fur Animal Breeding

1. Breed and strain crossing for production of fryer rabbits. Data from Fontana processed at Davis, in cooperation with the California Agricultural Experiment Station, include that from 1543 rabbits born alive from 213 litters. In the Californian X New Zealand White crosses, crossbred rabbits with straightbred mothers averaged 6.3 rabbits born alive per litter, 71% weaned and 3.8 pounds individual weaning weight compared with 6.4, 67%, and 4.0 pounds for straightbred rabbits with straightbred mothers. Comparable results of backcross rabbits with crossbred mothers were 7.6, 80%, and 4.0 pounds, respectively. A heterotic effect from the crossbred mother was evident. (AH fl-1)

2. Genetic and other factors affecting disease resistance in suckling rabbits. Data at Fontana for the period 1948-1961 were divided into two subperiods, August 1946 to August 1958 (period 1) and September 1958 to September 1961 (period 2). Each contained about equal numbers of observations. Mortality rate and age distribution of deaths from enteritis were similar for each period. However, there was a significant increase in death rate subsequent to 15 days of age from periods 1 to 2. Also, there was a significant increase in the death rate for pneumonia from period 1 to 2, largely due to an increase in the death rate prior to 15 days of age during period 2. Season of weaning, parity (age of doe expressed by litter sequence), fostering, and litter size, were analyzed as sources of variation in death rate. Only season of weaning had an important effect and that was on death from enteritis. This seasonal effect was entirely accounted for by a negative regression on ambient temperature. (AH fl-1)

3. Genetics of red cell antigens and serum protein polymorphisms in rabbits. Using the techniques of starch gel electrophoresis and histochemistry, three different patterns of esterases have been observed in the red cells of rabbits. The three patterns were named A, B and AB and are inherited as if controlled by a single pair of autosomal alleles Es^{A} and Es^{B} . The frequencies of the Es^{A} and Es^{B} are 0.32 and 0.68, respectively, in the New Zealand Whites and 0.06 and 0.94 respectively, in the Californian. (AH f1-1)

B. Fur Animal Physiology

1. Effect of breeding does at various intervals following kindling on reproductive performance. At Fontana a total of 78 does were subjected to test; 41 with a breeding interval of 10-12 days, and 37 with a breeding interval of 24-25 days following parturition. The results indicate that does subjected to these rapid breeding schedules did not perform satisfactorily. The reproductive lives of the does were shortened, they produced fewer litters per doe per year, and mortality among the young rabbits tended to be greater than in litters from does on a standard breeding schedule of from 5-6 weeks following parturition. (AH f1-6)

2. Reproduction in foxes. Reproduction was maintained at a high level on diets made up of unconsumed feed from mink. Twelve litters, born between May 13 and June 22 varied in size from 2 to 10. Seventy-four pups were born and 60 were raised to one month of age. (AH f1-3)

3. Mating systems for martens. No marten young were produced for the third consecutive year, although matings were observed each year. Positive sperm checks were obtained on four of five males. Various practices were tried, including placing one male with several females, and feeding special diets. The three wild marten added to the herd have not bred in captivity and continue to be antagonistic toward other marten. (AH f1-4)

4. Evaluation of fiber population in fur animals. Density of the follicle and fiber population is an important factor in determining the value of the pelt. At Beltsville, Maryland, the experimental biopsy gun was found to be the most valuable tool for taking the sample and the histological procedure the method of choice. (AH f4-3)

5. Barbiturate anesthesia in ranch mink. Physiological experimentation with mink often requires the use of anesthetic agents. Usual practice involves using drugs and dosages recommended for dogs. A study was conducted on 160 ranch mink at Ithaca to investigate the efficacy and possible toxicity of thiamylal sodium and pentobarbital sodium as anesthetic agents, and on 30 mink to determine the efficacy of analeptic, bemigrade, in reducing the recovery time from pentobarbital narcosis. Thiamylal sodium administered intramuscularly is not a suitable anesthetic agent for use in mink. Pentobarbital sodium administered intraperitoneally at a level of 35 or 40 mg/kg. induced

light anesthesia in over 88% of mink and deep anesthesia in 75% without mortality. The protracted recovery period following 45 mg/kg. intraperitoneally could be effectively shortened by a 40 mg/kg. intraperitoneally of bemigrade 45 minutes after the injection of the barbiturate. (AH f2-1)

6. Effect of light on reproduction of mink. Studies on the effect of additional length of day during breeding and gestation through implantation were carried out at Ithaca involving 800 adult and over 2500 young mink. Two hours of additional length of day were given to males and females starting approximately two weeks before breeding and continued until after implantation of kits took place. The average length of gestation was 55.7 days in controls compared to 51.3 days in the lighted mink. While these results are very promising, further investigations must be conducted before practical recommendations to commercial mink ranchers can be made. (AH f2-1)

7. Endocrine effects on pelage cycles in mink. The pituitary gland is required in the mink for normal pelage cycles as determined by a series of experiments with hypophysectomized animals at Madison, Wisconsin. Gonadectomy and thyroidectomy failed to affect pelage cycles. Administration of pregnant mare serum, lutenizing hormone, follicle stimulating hormone, unfractionated ovine gonadotropin, and thyroid powder to intact mink failed to alter normal pelage cycles. Hydrocortisone inhibited normal hair change. A wild mustelid, the short-tailed weasel (Mustela erminea bangsi) gave essentially the same response as mink to the above treatments. (AH f2-1)

C. Fur Animal Nutrition and Management

1. Development of mink diets based on sea fish and sea mammals. Diets containing 75% fish were compared with diets in which 10% fur seal meat replaced a like amount of fish and with diets in which the antioxidant, BHT and/or Ferrous Fumarate were added singly and in combination. Production varied from an average of 3.4 kits per female on the high fish plus BHT diet to 4.6 in the lot receiving fish, seal meat, BHT, and Ferrous Fumarate. Ferrous Fumarate effectively prevented the cotton pelt (anemic) condition and was beneficial to production. Thirteen percent more young were produced from the four lots which received this product. A level of 112 gms. of BHT per ton prevented steatitis but half that amount failed to stop heavy losses on high fish diets. There were no losses from steatitis where seal meat was fed but up to 50% of the animals were affected on fish and meat diets without BHT. Animals fed seal meat consumed slightly less feed and had higher weaning weights than those on all fish rations but the difference was not significant. (AH f3-1)

2. Feeding fresh water scrap fish to mink. Studies of methods to obtain the maximum utilization of raw fish from the Great Lakes (trawler chubs and alewives) were continued during the growth period of 1964 and the reproductive season of 1965. During the growth period 100 dark females and 90 dark males were allocated to 5 groups receiving diets of (1) ocean fish, (2) 30% alewife presscakes, (3) 30% cooked alewife, (4) 30% raw chub, and (5) 30% cooked chub. Final weights were comparable between the various groups but were less than the controls. The reproductive performance was not as satisfactory on the alewife or chub diets as in the control group. The reason for the poor performance of the mink on these diets is unknown. The possibility of agricultural or industrial contamination products, such as DDT, being present in the Great Lakes fish and not present in ocean fish is currently being investigated. (AH f3-1)

3. Digestibility of mink feeds. The determination of the protein, gross energy and dry matter digestibility of feeds available for use in mink diets is of great practical and economic value to the mink rancher. Digestibility studies were conducted on cattle and horse muscle and viscera products, poultry byproducts and viscera, several species of fish, dairy products, and desiccated live protein feeds. Several products not previously considered as good diet ingredients gave evidence of being desirable, especially from the standpoint of protein digestibility. (AH f3-5)

4. Protein requirements of rabbits. To further evaluate the protein requirements of rabbits for meat production, an experiment was conducted utilizing five diets analyzing 17.1, 17.5, 18.3, 19.4, and 20.9% crude protein on an "as fed" basis. Criteria analyzed were: number of young weaned per litter, mean weight per rabbit weaned, kilograms feed consumed per rabbit weaned, and kilograms feed per kilogram of weight weaned. No significant differences were evident among the protein levels for any of the criteria. It appeared that the crude protein requirement was met at the lowest level of 17.1% which would correspond to 19% on a dry matter basis. (AH f3-2)

5. Effect of nitrogen fertilizer on the nutritive quality of Bermudagrass. This investigation was conducted in cooperation with the University of California at Riverside. Ammonium nitrate fertilizer (32.5% N) was applied to Bermudagrass pastures at the ratio of 0, 100, and 250% N per acre on a plot laid out in three replications. For treatment diets, alfalfa hay was replaced by Coastal Bermudagrass hay fertilized at the three levels. The results indicate that diets containing fertilized Bermudagrass contained levels of nitrogen nitrate that appeared to be toxic to rabbits, and which may interfere with availability and utilization of vitamin A. The results thus suggest that rabbits may be quite sensitive to high nitrate levels, and their use in evaluating the supply of metabolizable energy in forage crops or for obtaining data on feed conversions should be carefully examined. (AH f3-2)

6. Distillers grains and solubles as plant protein supplements in the rabbit diet. Distillers dried grains and solubles when used as the only supplemental sources of plant protein in rabbit diets, produced no beneficial effects on number of young weaned per litter, weaning weight, or palatability. Conflicting results were obtained with respect to feed efficiency and number of viable young at birth. Distillers grains and solubles were not satisfactory replacements for soybean meal as the sole supplemental plant protein source. However, the addition of 10 or 30% distillers grains as replacement for part of the grain mixture gave satisfactory results. (AH f3-4)

7. Supplemental vitamin E in rabbit diets. Does were randomly assigned to three groups, receiving a control diet (Group 1), the control diet supplemented with 10,000 units of vitamin E per ton (Group 2), and the control diet supplemented with 20,000 units of vitamin E per ton (Group 3). The does were maintained on these diets through several successive litters. On the basis of the results it appears that supplemental vitamin E increased the average number of live young born per doe which might be explained on the basis of an intrauterine effect, reduced the average number of young born dead, increased the number of young weaned per doe, had no effect on individual weaning weights of the young, reduced doe mortality, and reduced mortality of the young between the ages of 22 - 56 days when the young are out of the nest box and consuming the pelleted feed. Therefore, it seems that although individual weaning weights were not increased, total production per doe per year might be increased with the use of supplemental vitamin E. (AH f3-2)

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AREA NO. 20: ANIMAL PERFORMANCE AND MANAGEMENT RECORDS

Problem. Effective livestock and poultry improvement cannot be accomplished effectively without adequate records of performance and management. In order to have widespread utility, these records must be produced through carefully coordinated programs yielding uniformity in measurements, standardized analytical procedures, and accuracy and integrity in animal identification and genealogy. Continual revision of uniform data collection, reporting and evaluation techniques in accordance with current research findings requires integration of program operations and research. Only in this manner can there be a continual chain of discovery, field testing, and application with the needed genetic and environmental improvement.

USDA AND COOPERATIVE PROGRAM

This is a continuing long-term program of performance testing dairy cattle and poultry, including the evaluation of the genetic merit of dairy cows, sires and herds, chickens for egg or meat production, and turkeys. Also included in the program is the control of egg-transmitted poultry diseases. The work on dairy cattle performance testing is cooperative with 50 States and Puerto Rico and the Records and Breeding Committees of the American Dairy Science Association. Cooperation is also carried out with the National Association of Animal Breeders and the various dairy cattle breed registry organizations. The poultry work is cooperative with Official State Agencies in 47 States and with the supervisors of 25 random sample tests in the United States and Canada.

The Federal scientific effort devoted to the programs in this area totals 7.0 professional man-years. Of this number, 5.0 are devoted to dairy cattle performance testing and 2.0 to poultry performance testing.

PROGRAM OF STATE EXPERIMENT STATIONS

The effort of the State stations in this area is quite large. It is difficult, however, to make a manpower estimate which would be distinct from that in breeding sections. As the USDA material indicates, much of the effort in DHIA and in poultry testing is cooperative with the States. At several State stations, DHIA records are processed for dairymen on a reimbursable basis. Data derived is used in estimation of genetic parameters, etc., by resident investigators. Similarly, the random sample poultry tests on broiler and egg production strains conducted at State locations provide information on performance and mortality of commercial stocks. Eggs and meat from these poultry tests are used in detailed studies such as strain comparison of chemical constituents and correlations of these items with production traits.

Animal performance and management records with beef cattle, swine, and sheep are frequently obtained through cooperation with producers, extension service, and industry. In several States, swine testing stations have been established and operated on a self-sufficient basis supported by fees. Research personnel often act in an advisory capacity. In many States, programs of on-the-farm performance and progeny testing of beef cattle have been developed. Again, research and extension people frequently cooperate in this endeavor. At central facilities in some States, bulls belonging to producers are tested for growth and feed efficiency often under the direction of research personnel. Similarly, a limited number of ram testing stations have been developed for indicating growth rate.

No estimate of State station professional man-years is made.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Dairy Cattle

1. Sire evaluation program. A total of 1,685,797 records of performance reported during the year, along with the 11 million records available in magnetic tape files, were used in producing 18,533 individual genetic appraisals of sires. From these, the dairy industry and cooperators were provided with 59,963 sire records. These genetic appraisals were made on a quarterly basis and included all sires qualifying with five or more progeny having herdmates. A total of 1,262,814 progeny were included in the genetic appraisals. (AH i4-1)

2. Cow evaluation program. Genetic appraisals of the registered cows in DHIA were made and the resulting indexes of performance made available to the industry on a semiannual basis. A total of 550,000 cows were indexed biometrically and the top 2% identified. This indexing procedure provides the industry with a reliable and uniformly derived estimate of breeding value. These sire and cow evaluations will be especially adaptable to genetic improvement through artificial insemination. (AH i4-1)

3. Dairy recordkeeping programs. The 1,424 dairy herd improvement associations, employing 2,439 supervisors, provide the organizational structure for visiting farms and for reporting data in the 50 cooperating States. Participation in the National Cooperative Dairy Herd Improvement Program continued to expand and was as follows:

<u>Plans</u>	<u>Herds</u>	<u>Cows</u>
Standard DHIA	40,075	2,087,581
Owner-Sampler	26,604	818,406
Weigh-a-Day-a-Month	<u>1,229</u>	<u>56,570</u>
Total	67,908	2,962,557

A total of 1,685,797 records of performance was reported to the Dairy Cattle Research Branch for use in the genetic appraisal of cows and sires and for research.

The artificial breeding program, through which the superior sires developed and recognized in DHIA herds are utilized, bred a total of 7,282,994 dairy and 464,959 beef cows. This represents 41% of the Nation's dairy cows of breeding age. An average of 3,053 cows per sire were inseminated during the year. The total of 7,747,953 cows were inseminated by 2,538 bulls. (AH i4-2)

4. DHIA record analysis and research.

(a) Recordkeeping statistics. Cows in standard DHIA herds produced 11,976 pounds of milk and 457 pounds of milk-fat per cow-year in 1964-65, and exceeded cows not enrolled in recordkeeping by 4,708 pounds of milk. The rate of yearly increase in milk yield of DHIA cows during the past 3 years has been 98% more rapid than for non-DHIA cows.

Cows in DHIA continue to be fed higher levels of feed, and provided an estimated income over feed cost of \$295 per cow. This return compares with an estimated income over feed cost of \$284 in 1963-64; \$279 in 1962-63; and \$295 in 1961-62. (AH i4-3)

(b) Reliability of early sire evaluations. An analysis of 277 heavily tested AI bulls was made in order to determine the frequency, degree, and source of negative bias in sire summaries. A low level bias was found, and its removal affected by implementing a procedure which will delay the use of lactation records until the majority of progeny calving at the same time are available. It was also found that the first AI daughters of a bull are representative of his transmitting ability for production. (AH i4-3)

(c) DHIA 305-day projection factors. A set of multiplicative factors were developed for nationwide use in further standardizing DHIA lactation records for cow-days in milk. It was necessary to develop and use a total of 6,960 factors, one for each breed, day in milk (15 to 304), age group, and milk and milk-fat yield. These factors will significantly increase the usefulness of all DHIA records of performance, both on-the-farm and in research studies. (AH i4-3)

(d) Evaluation of age correction factors. A study of the paired and gross comparison method of determining age correction factors was made using production data grouped by region. The deviation between gross and paired regressions on age was found to be noticeable only for the Western Midwest and Plains areas. In most instances, however, and particularly at ages beyond maturity, the standard and presently used DHIA age factors offer a reasonable compromise between those derived by the gross and paired methods. (AH i4-3)

(e) Usefulness of records of dams in the evaluation of sires in artificial insemination (AI). DHIA data representing 24,853 daughter-dam comparisons for 263 Holstein AI sires were studied to determine if the use of data from dams (mates of sires) will increase the reliability of a sire's evaluation. The relative ranking of the bulls was the same (rank correlation = + .998) when daughters' deviations alone were used, as when both daughter and dam deviations were employed for ranking; although there was a mean bias of 41 pounds of milk per sire due to selection of mates. These results demonstrate that dam-herd mate comparisons need not be added to daughter-herdmate comparisons when genetically evaluating AI bulls. (AH i4-3)

B. Poultry

1. National Poultry and Turkey Improvement Plans. Over 14.4 thousand flocks containing 32.9 million breeding chickens and 1.9 thousand turkey flocks containing 3.7 million birds were officially classified under National Plan standards. All flocks qualified for a disease control classification and 94.4% of the chickens and 97.3% of the turkeys were also classified under one of the breeding phases of the Plans. These birds produced hatching eggs for 1,418 chicken hatcheries with incubator capacity of 316 million eggs, and 325 turkey hatcheries with capacity for 52.2 million eggs.

More than 16.8 thousand prospective breeding flocks containing 37.0 million birds were tested for pullorum disease and fowl typhoid. The number of reactors to the initial blood test reached an all-time low for both chickens and turkeys. The percentage of chicken reactors dropped from .0055 to .0044, while turkey reactors declined from .0047 to .0024%. Cooperating diagnostic laboratories reported 277 isolations of pullorum and typhoid organisms. Approximately one-half of these cases were followed up with field investigations by cooperating State agencies. With the continued cooperation of the diagnostic laboratories and State agencies, it is expected that increasing numbers of these infections will be traced to their sources and eliminated as potential disseminators of these two diseases.

Cooperating laboratories report the diagnosis of paratyphoid as well as pullorum and typhoid. During recent years the reports show a steady decline in pullorum-typhoid, while the incidence of paratyphoid has increased rapidly. In 1964, laboratories reported 1,108 cases of paratyphoid, as compared to 397 in 1960. These reports have shown *S. typhimurium* to occur frequently in turkeys. A program for the control of *S. typhimurium* was incorporated in the NTIP late in 1964. The laboratory reports also indicate a rapid increase in the incidence of paracolonic infection during the last few years. As yet, no organized program for the specific control of paracolons has been adopted.

Provisions for a *Mycoplasma gallisepticum* (PPL0) control program in the Turkey Plan became effective in November 1964. However, participation in the program was limited until an approved antigen for conducting the blood test became available early in 1965.

The trend toward greater use of cross-mating in chick production continued during 1964-65. More than 3/4 of all chickens in participating flocks were in cross-matings. Conversely, less than 2% of the turkey breeding flocks were cross-mated. The growing acceptability of the large white turkey is reflected in 1964-65 participation reports, which show that for the first time, the number of large white turkeys exceeded the number of Bronze.

Reports of exports of hatching eggs, chicks, and poults show that approximately 10% fewer units were shipped to foreign countries in 1964 than in 1963. However, exports of products to be used for breeding purposes were 30% greater in 1964 than in the previous year. (AH e5)

2. Random sample performance tests. Data from 17 United States and 4 Canadian random sample egg laying tests were submitted to the Poultry Improvement office in 1964. The 1963 and 1964 data were combined into a two-year summary. This combination of data over the two-year period permitted comparison of the performance of 106,397 laying hens in 1,582 pens, and 143 different stocks tested at 63 locations in the United States and Canada. The combining of data obtained over a two-year period permitted more reliable predictions of the performance of stocks than the use of a single year's data. The results of these computations, expressed as regressed means, are predictions of what the performance of a stock would be, had it been tested at all 63 locations over the two-year period. These regressed means, along with the statistical significance of differences, expressed as 80% confidence limits, were computed for 16 economic traits of each stock tested.

The supervisors of four Random Sample Turkey Tests submitted records on 4,200 individual turkeys, representing 42 entries of 32 different stocks that were tested in 76 pens. These data were analyzed separately by tests, and Duncan's Multiple Range Test was applied to 12 traits to show the statistical significance of difference between entries within a test. (AH e5)

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AREA NO. 21: PRODUCTION INFLUENCES ON ANIMAL PRODUCTS

Problem. Beef, lamb, pork, and poultry are excellent sources of wholesome and digestible animal proteins and fatty acids necessary in maintaining a healthy, appetizing diet. However, these meats must be of high quality, as well as in plentiful supply, if they are to retain their high position and esteem in the minds of consumers. Proper finish, a high proportion of lean, with adequate intramuscular fat, tenderness, full flavor, and color desired by the consumer are the goals the meat producer must strive to attain through breeding, feeding, and management. The quality of cuts and kind of meat are directly reflected in the demand and in the price of the product.

Egg shell strength and yolk quality, strength of wool, fatness, quantity, flavor, color, and tenderness of meat are all known to be influenced by production practices. However, these quality characteristics and many more are not well understood, even though they are of considerable economic importance. Effective measures of evaluating quality differences are of great importance in determining the nature and effect of production practices on the products.

USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by food product technologists, wool and fiber technologists, biochemists, chemists, physiologists, statisticians, and animal husbandmen engaged in both basic and applied research designed to develop methods and information which will be useful in evaluating quality and quantity of animal products and will be useful in aiding and directing livestock production. Research on beef, veal, lamb, and pork is directed at the influence of selection and breeding, nutrition, physiology, management, and other production variables on carcass and meat quality and quantity. Standards are being applied and adapted for appraisal of slaughter animals, of carcasses, and of meat cuts. The objective of the work with poultry and eggs is to ascertain those factors of nutrition, breeding, and management which contribute to the initial quality of poultry products and their capacity to retain that quality. Studies with wool, fur, and fiber are conducted to determine the physical, chemical, and biological structures and properties of wool and other animal fibers as influenced by production factors. The work is conducted at Beltsville, Maryland; Dubois, Idaho; Fort Wingate, New Mexico; Glendale, Arizona; and in cooperation with four State experiment stations. Cooperation is also carried out with the Eastern and Western Utilization Research and Development Divisions, the Human Nutrition Research Division, the Agricultural Engineering Research Division, and the Market Quality Research Division.

PROGRAM OF STATE EXPERIMENT STATIONS

Beef. The influence of feeding and management treatments on carcass and meat characteristics include fattening on grass, drylot, or combinations of these; varying the length of heavy silage feeding preceding finishing with a high-energy ration; creep feeding versus no creep feeding during the nursing period, and various combinations of ration ingredients with and without adjuvants. Many of the projects include economic considerations as well as consumer acceptance and laboratory analysis for quality. Regional project NC-58 is designed to objectively identify the factors that characterize differences in beef carcasses, evaluate the relative importance of these factors, and find the best indicators of these carcass traits in the live animal.

A number of breeding projects contributing to regional research projects NC-1, W-1, and S-10 are designed to determine the effectiveness of selection in improving carcass traits. Other independent studies include the importance of beef conformation as contrasted with dairy type in the production of consumer acceptable beef.

Lamb, Mutton, and Chevon. A limited amount of research is concerned directly with the influence of nutrition and management on quality of lamb produced, but a concerted effort is being made in the western region under W-61 to define and measure carcass quality and to determine the effectiveness of selection for muscular development. Several stations are studying the pattern of growth in different breeds and crosses as affected by feed, sex, and type of birth. NC-50, while basically a breeding project, has as its primary objective improvement of the lamb carcass.

Pork. A majority of projects discussed in the Nutrition and Management and Breeding problem areas include appraisal of the end product--the carcass. Research at some stations, however, has as its primary objective the influence of varying ratios of protein to energy and total feed consumption on carcass characteristics, and an evaluation of various criteria of selection for superior meat-type swine.

Poultry and Eggs. Research on egg quality includes work on the causes and prevention of blood and meat spots and undesirable yolk coloration. Egg shell quality must be good in order to maintain high interior quality in market channels, and the effects of nutrition, heredity, and environment on egg shells are being investigated. The effects of different egg washing techniques on interior quality are also being evaluated. Research is underway on the effect of nutrition and management on chicken and turkey carcass quality traits such as skin pigmentation and a desirable amount of fat.

The total State scientific effort devoted to production influences on animal products research is 45.0 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Beef

1. Tenderness evaluation techniques. A study of cooking methods for beef steaks in tenderness studies indicated that variability could be reduced markedly by broiling for 46 minutes at an oven temperature of 175°C, instead of broiling to an internal temperature of 80°C. There were no significant differences in the palatability scores for the two methods. However, there appeared to be better agreement among judges for individual samples, and the judges were better able to reproduce their evaluations on replicate samples. When time constant cooking was used, the observed differences were due almost entirely to sample differences.

A chemical analysis, before and after cooking of selected muscles, judged by the panel to be very tough or very tender, indicated that the acidic groups in meat are responsible for a major portion of the buffering capacity of meat. The buffering capacity of meat between pH 7.0 and 2.5 increases during cooking as would be expected if the protein molecules were being denatured. While the acid buffering capacity for raw and cooked meat differ, the relationships between raw samples parallels that of the cooked samples and could be used to predict the behavior of cooked samples. A moderate correlation exists between tenderness and acid buffering capacity, at least when extremes are studied. (AH d4-5)

The tenderness press was modified by replacing the intermittent pressure increase system with a constant-flow rotary vein pump. Based on tests with 375 beef rib roasts, this modification increased the effectiveness of this instrument in measuring tenderness. Correlations between the panel tenderness score and the tenderness press were $r = .13$ for the original, and $r = .35$ for the modified press.

Objective tenderness measures (Warner-Bratzler, STE puncture and shear, and tenderness press) correlated more closely with panel tenderness score for Standard and Utility grades of beef than for Choice and Good grades. Carcass grade and objective tenderness measures, respectively, accounted for 8.1 and 43.8% of the panel score variance among 306 beef rib roasts using the modified tenderness press as one of the four objective measures. (AH d4-4)

2. Composition. Continued studies of estimating carcass yield, selected linear carcass measurements as estimates of wholesale cut yield and composition indicate the measurements are of value. The data showed the cross-sectional shape of the P. major muscle to be that the mathematical considerations of the shape as an ellipse produced a good fit as compared to actual area as determined from a tracing. The results indicated distinct breed differences in area of P. major and total separable lean in 9-11 rib samples. For example, the simple correlation between calculated

area of P. major and total lean in the 9-11 rib sample was .91 for Angus, .84 for dual-purpose Shorthorn, .82 for Hereford, .81 for Jerseys and .75 for Holstein. (AH d4-7)

The average computed percentage yield of trimmed, boneless major cuts of 139 beef carcasses and 21 dairy cow carcasses grouped by grade were: Prime, 49.8; Choice, 50.3; Good, 51.3; Standard, 53.1; Utility, 53.9% for the beef-type carcasses; and Commercial, 52.9; Utility, 52.6% for dairy cow carcasses. The computed percentage yields of the cuts of beef-type carcasses were not significantly greater than those of dairy cow carcasses of a similar grade. However, the beef-type carcasses had a significantly higher yield of major cuts in the Standard and Utility than in the Good and Choice grades due to differences in fatness. (AH d4-7)

Ultrasonic measurements of depth of fat and lean over the twelfth rib of finished beef animals measures with acceptable accuracy the depth of fat covering, but not the degree of thickness of muscling. (AH d4-7)

3. Quality in beef muscle

(a) Juiciness. Water-holding capacity is a characteristic of meat tissue that may have a relation to the ability of proteins to "bind" water during aging and cooking. Some meat research workers believe that water-holding capacity is also related to juiciness of the cooked tissue. To test these ideas, 89 beef samples were evaluated for juiciness by panel. Values for centrifugally extracted moisture (CEM) ranged from 15.3 to 32.4% and averaged 24.8%. The CEM values correlated significantly with the panel juiciness score ($r = .44$) and overall desirability score ($r = .32$). Thus juiciness and water-holding capacity have a definite and positive relationship. (AH d4-6)

(b) Electrical properties. Data on electrical properties of approximately 100 beef carcasses have been recorded at three post-mortem intervals. Brass and silver electrodes were used. Preliminary evaluation of the data indicates that, immediately post-mortem, certain electrical properties may be curvilinearly related to specific characteristics of tissue after heating. (AH d4-6)

(c) Method of preparation. Deep-fat frying vs. oven roasting, has shown a decided advantage in favor of deep-fat frying for bringing out differences in palatability of beef. Differences in flavor, juiciness, tenderness, and overall desirability were noted between breeds and certain lines of cattle when one-inch steak samples were heated in deep-fat. However, when 9-11 rib roasts from these same animals were compared, only tenderness differences were found. (AH d4-4)

B. Lamb, Mutton, and Chevron

1. Composition. The usefulness of three indices to determine lamb carcass composition as represented by the 9-rib rack composition, were evaluated with data from 38 lambs. The indices used were chilled carcass weight, area of longissimus dorsi muscle, and calculated volume of leg muscle. The volume of the leg muscle was calculated from length and thickness measurements of the dressed lamb carcass. Correlations between lean of the rack and chilled carcass weight, area of longissimus dorsi muscle, and leg volume were .95, .80 and .75, respectively. Correlations between separable fat of the rack and these same three indices were .87, .56 and .69, respectively. Correlations with bone in the rack were .85, .72, and .69, respectively. These results indicate that chilled carcass weight is useful as a measure of yield of separable lean, fat, and bone in dressed lamb carcasses weighing 35 to 50 pounds. (AH b6-1)

Research to find and develop new, non-destructive methods of accurately measuring live animal composition, using short-half life isotopes of ^{24}Na and ^{42}K , has indicated that these isotopes could be used to estimate body electrolyte pools of the two elements in living lambs. Carcass analysis indicated that the size of the Na and K pools is related to a measure of body water. Results of these experiments have also shown that a better understanding of both sodium and potassium metabolism in the sheep is needed to provide an accurate evaluation of the experimental errors associated with this method. (AH b6-1)

2. Quality of lean. A study was made to investigate the amino acid changes that might be accompanied by physiological stress due to pre-slaughter electrical immobilization. Separation of the free amino acids of plasma by thin-layer chromatography showed that the relative concentrations of iso-leucine decreased and that of valine increased significantly when sheep were immobilized by electric shock. Total plasma amino acid nitrogen was not changed. It appears that preslaughter stress, due to electrical shock, has certain characteristic influences on electrolyte, amino acid, and possibly glucose metabolism. The influence of these metabolic changes on the carcass quality is not known. (AH b6-1)

3. Factors affecting carcass merit in lambs. A total of 209 range ram and wether lambs from four different breeding groups were self-fed on two pelleted rations at the New Mexico Agricultural Experiment Station. The rations were either 100% alfalfa, or 60% alfalfa and 40% milo grain. Breed groups, ration, and carcass weight were important sources of variation in yield of untrimmed prime cuts. Sex and carcass weight were the main sources of variation for both trimmed cuts and total retail cuts. Ram lambs produced greater yields of these cuts than wether lambs. It was also noted that the fastest growing lambs produced the greatest amount of lean meat. Loin eye area was not affected by any of the variables measured except carcass weight. Tenderness did not appear to be greatly affected by any of the sources of variation studied, although wethers on the 100% alfalfa ration did have the lowest shear force values. (AH b1-10,11,12)

C. Pork

1. Tenderness and palatability evaluation techniques. Cross-sectional variations in tenderness were observed among 97 pork loin roasts using the slice tenderness evaluator (STE). The lateral location of the longissimus dorsi muscle in the roasts (3 thoracic and 3 lumbar vertebra) had lower STE values and was markedly more tender than the medial or dorsal locations. However, the less tender medial and dorsal areas gave STE values that correlated more closely with panel score than values for the more tender lateral locations. In a second study of 70 pork loins, the STE accounted for twice the variance in panel tenderness score as that accounted for by the Warner-Bratzler shear, the universally accepted measure of objective tenderness. Pork differed from beef regarding the area of most and least tenderness in the l. dorsi muscle. (AH a4-3)

A study designed to evaluate panel sensitivity to certain organoleptic factors in pork roasts was undertaken. The experimental samples were taken from the carcasses of 128 pigs used in a growth and management study. Breeding and energy restrictions significantly affected the tenderness and other palatability characteristics of pork loins. Duroc pigs were significantly more tender, juicy and generally more desirable than Yorkshire pigs. Ten generations of selection for or against back-fat thickness had no significant effect on palatability scores of the loin. However, when the energy intake was restricted to three-fourths of requirements on one-half of the pigs in the study, the panel rated them much lower in tenderness, juiciness, and overall desirability. They also detected a significant decrease in tenderness with age. Differences in tenderness due to breeding and management, and panel juiciness scores accounted for 69% of the variation in panel overall desirability score. (AH a4-3)

Samples of cooked pork from 46 pork loins were studied for centrifugally expressed moisture (CEM) water-holding capacity using a technique recently developed by this Laboratory. Although the CEM values did not directly reflect the juiciness of the meat as measured by taste panel, the means were usually higher for samples receiving higher juice quantity scores. Pork samples that were moderately juicy, slightly dry, and dry gave CEM values of 16.1, 16.4 and 14.8% moisture extracted. There appears to be two types of juiciness, one in which the meat is incapable of retaining the moisture in the tissues and another that is slightly lower in moisture after cooking. In the former type, the juice is "watery" and is lost just as the meat is sliced for serving, while in the latter type, there is an excessive loss of moisture during storage and cooking. This would account for the discrepancy between juiciness scores and CEM values noted for pork. (AH a4-3)

2. Carcass evaluation. A least squares analysis of 23 pork carcass and cut linear measurements on 97 hogs slaughtered at 50-pound intervals from 75 to 275 pounds, has been completed. The carcass and cut measurements included length, depth, and width -- all taken from definite anatomical locations. Mean differences between weight groups were statistically significant for all measurements. When the data were pooled for each, the mean differences between barrows and gilts were significant for width of shoulder and ham, and length of loin. (AH a4-3)

An extensive statistical analysis is being made of growth data from 56 Poland China pigs divided into two groups according to degree of finish. Preliminary analysis indicates that different muscles have significantly different rates of development when plotted against total lean. There is apparently no significant difference between rates of growth of the same muscle for the two groups, although there is a definite individual muscle weight difference at each age interval. (AH a4-3)

3. Color. Research on color in pork as influenced by heredity, sex, age, feeding, and management was continued as a PL 480 study with the Institute of Animal Physiology and Nutrition Laboratory of Animal Products, Polish Academy of Science, Warsaw, Poland. The results show that color of meat is determined by several physical and chemical properties. The major ones are pigment content, water-holding capacity, pH, and moisture content. The dominant wavelength of light in meat color depends on pH. Saturation is determined by content of pigments, water-holding capacity, and moisture content. Lightness is conditioned by water-holding capacity, concentration of pigments, and pH. Color stability of raw meat is dependent on its water-holding capacity and reducing activity. A high relationship between color stability and water-soluble SH-groups points to the part played by those groups in post-mortem color changes in meat.

No significant relationship was detected between accommodations (reared in sties vs. paddocks with huts) and associated properties of the meat. Feeding on different kinds of rations (barley, rye, potatoes, etc.) did not result in differences in color, provided the ration was equalized with respect to energy and protein level.

Pigs display considerable differentiation in respect to post-mortem lactic acid production in the carcasses. Lightness of color was the only color attribute associated with pH measured 45 minutes after slaughter.

There was no relationship between protein-bound iodine in the serum of pigs and pH measured 45 minutes post-mortem. This indicates that contrary to some opinions the reason for meat being pale, soft, and exudative are not to be found in a weakened action of the animal's thyroid. (E 21-AH-2)

D. Poultry and Eggs

In a study of eggshell weight, different methods of reducing variability were considered. It was observed that the variability, as measured by the variance and the correlation coefficient was reduced by calculating the ratio between the part and the whole less the part. This was especially noticeable with the albumen, a major component of the whole. (AH e4-10)

E. Wool and Fiber

1. Factors affecting quality and value of wool. Continued studies on the relationship between quality traits and economic factors affecting the value of graded lines of grease wool confirmed results of previous years except for some changes in price. The 64/70's staple fleeces were two pounds heavier, had 3% higher clean fiber content, were 0.8 inches longer, 0.9 microns coarser and brought 9.5¢ per pound more than 64/70's French combing wool. The 60/62's staple wool was 3.1 microns finer, .26 inches shorter, had 0.5% lower clean fleece content and brought 7.3¢ per grease pound more than the 56/58's staple wool. Crutchings averaged about 0.8 pound per fleece and had a grease value of 7.5¢ per pound less than the 56/58's fleeces. (AH b5-2)

2. Measuring methods to evaluate wool. At Beltsville, Maryland, data from Merino and Shropshire wool showed that there were significant interactions between sheep and regions on the sheep, in each breed; between sheep and lock levels; and between regions and lock levels in the Merinos. Therefore, a satisfactory basis for differentiating among fleeces can be obtained from measurements of crimp pattern at three levels, on subsamples from one lock from each of three regions by at least two operators. Refinements to this method resulted in the preparation of a tentative standard for the American Society for Testing Materials.

The Electronic Fiber Fineness Indicator (EFFI) designed for measuring fineness and variability of wool is ready for testing on known samples of top at Beltsville, Maryland. Modifications have been made in the original equipment to increase the readout capacity and provide more accurate measurement of fineness.

Preliminary studies have been made at Beltsville on the feasibility of using the air-flow instruments for determination of fineness of mohair. These studies indicate that the fineness of mohair can be determined equally as well as that of wool by increasing the weight of the sample to be tested in the instruments.

Modification has been completed of the cutting instrument for use with the Coulter Counter at Beltsville in order to improve the efficiency of the instrument in preparing samples for determination of fineness and variability in the Coulter Counter.

The feasibility of determining strength of grease wool locks by use of the instron has been demonstrated at Beltsville. Testing is now underway to utilize a new type of jaw to increase the speed of testing and the reliability of results through elimination of slippage of fibers. (AH b5-3)

3. Relation of fleece traits to processing characteristics. Studies on the relationship among quality traits, yield and quality of top, were continued on 14 breed grade lots of 15 mature ewe fleeces each from Dubois, Idaho. They were scoured at the University of Wyoming and processed into top at the Philadelphia College of Textiles and Science. Results were almost identical with those from previous years. In general, staple length, grease fleece weight, and percent clean yield increased and crimps per inch decreased with increasing fiber diameter. Staple length of grease locks averaged 0.1 inches longer and grease wool fineness averaged 0.6 micron finer than the resulting top. Tops from coarser wool were more variable in average length and diameter. (AH b5-7)

PUBLICATIONS -- USDA AND COOPERATIVE RESEARCH

Beef

Alsmeyer, R. H., Bollinger, N. C., Thornton, J. W., and Hiner, R. L. 1964. Electrical properties and beef palatability. J. Animal Sci. 23(1):858. (Abs.) (AH d4-6)

Alsmeyer, R. H., Thornton, J. W., Hiner, R. L., and Bollinger, N. C. 1965. Some dorsal-lateral location tenderness differences in the longissimus dorsi muscle of beef and pork. J. Animal Sci. 24(2): 526-530. (AH d4-4)

Hiner, R. L. 1965. Slaughtering, Cutting, and Processing Beef on the Farm. Farmers' Bul. No. 2209. (AH d4-4)

Oltjen, R. R., Davis, R. E., and Hiner, R. L. 1965. Factors affecting performance and carcass characteristics of cattle fed all-concentrate rations. J. Animal Sci. 24(1):192-197. (AH d4-7)

Lamb

Lynch, G. P., Fries, G. F., and Hiner, R. L. 1965. Some preliminary observations on the use of ^{24}Na and ^{42}K for predicting the carcass composition of live sheep. J. Animal Sci. 24(3):865. (Abs.) (AH b6-1)

Pork

Alsmeyer, R. H., Thornton, J. W., and Hiner, R. L. 1965. Cross-sectional tenderness variations among six locations of pork longissimus dorsi. J. Food Sci. 30(1):181-183. (AH a4-1)

Hiner, R. L., Thornton, J. W., and Alsmeyer, R. H. 1965. Palatability and quantity of pork as influenced by breed and fatness. J. Food Sci. 30(3):550-555. (AH a4-1)

Thornton, J. W., Alsmeyer, R. H., and Davey, R. J. 1965. Genetics, diet and pig age effects on pork quality. J. Animal Sci. 24(3):869. (Abs.) (AH a4-1)

Wool and Fiber

Houriham, M. E., Harvey, W. R. and Terrill, C. E. 1965. Evaluation of a method of measuring staple crimp of grease locks from individual fleeces. J. Animal Sci. 24(1):5-9. (AH b5-3C)

Line Project Check List -- Reporting Year July 1, 1964 to June 30, 1965

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl. In	
				Summary of Progress	Area & Subheading
AH a1 AH a1-8	Swine Breeding Investigations Selection for combining ability of three lines of swine	Stillwater & Ft. Reno, Okla.	J. A. Whatley, Jr., & C. E. Shelby	Yes	16-A
AH a1-9	Inbreeding, linecrossing, and selection within and between the Hampshire, Duroc and Yorkshire breeds of swine	Brookings, Eureka, & Centerville, S. Dak.	J. W. McCarty & C. E. Shelby	Yes	16-B-1
AH a1-10	Methods of breeding and selection in swine	Madison, Wisc.	A. B. Chapman & C. E. Shelby	Yes	16-A
AH a1-11	Recurrent reciprocal selection for high specific combining ability in crosses between Yorkshire and Montana No. 1 swine	Miles City, Mont.	C. M. Kincaid, H. O. Hetzer & E. V. Krehbiel	Yes	16-B-2
AH a1-12	Selection for high and low degrees of fatness in swine	Beltsville, Md.	C. M. Kincaid & H. O. Hetzer	Yes	16-A 16-B-1
AH a1-13	Reciprocal recurrent selection for general and specific combining ability in two strains of swine	Beltsville, Md.	C. M. Kincaid & H. O. Hetzer	Yes	16-A 16-B-2
AH a1-16	Effectiveness of selection in purebred and crossbred foundation stocks	Urbana, Ill.	H. W. Norton & C. E. Shelby	No	
AH a1-17	Selection, inbreeding and crossing for swine improvement	Duluth, Waseca, Morris, Crookston, Grand Rapids & Rosemount, Minn.	R. E. Comstock, W. E. Rempel & C. E. Shelby	No	
AH a1-18	A comparison of selection procedures within lines of swine used for crossbreeding	Lafayette & Farmland, Ind.	V. A. Garwood & C. E. Shelby	No	
AH a1-19	Exploration of metabolic pathways that interrelate biochemical and genetic differences in swine populations	Beltsville, Md.	C. M. Kincaid	Yes	17-A-1 17-B-1,2,3
AH a1-20	The nature of genetic variability in gene pools of swine	Lincoln, North Platte & Scotts Bluff, Nebr.	L. J. Sumption & C. E. Shelby	Yes	16-A 16-B-4 17-A-2
AH a1-21	Effects of selection for low back-fat thickness on various performance traits and carcass desirability in swine	Columbia, Mo.	J. F. Lasley & C. E. Shelby	Yes	16-A 16-B-1 17-A-3,4 17-B-4
AH a1-22	Genetic relationships between purebred and crossbred swine	Ames & Ankeny, Ia.	L. N. Hazel & C. E. Shelby	Yes	16-B-5,6 21-A-1,2
AH a1-23	Selection for maximum genetic improvement in swine with a minimum of expenditures	East Lansing, Mich.	W. T. Magee & C. E. Shelby	No	
AH a2 AH a2-3	Swine Management Investigations Evaluation of new or improved type of hog-rearing equipment	Beltsville, Md.	C. M. Kincaid & J. W. Stevenson	No	
AH a2-5	The evaluation of management practices as they affect swine production	Beltsville, Md.	C. M. Kincaid & J. W. Stevenson	Yes	18-C
AH a2-6(C)	Control of flies and other insects associated with swine production without the use of insecticides*	Lafayette, Ind.	C. M. Kincaid	No	

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Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl. In	
				Summary of Progress	Area & Subheading
AH a3	Swine Feeding and Nutrition Investigations				
AH a3-12	Trace mineral requirements and biochemical pathways relating to mineral utilization by swine	Beltsville, Md.	I. P. Earle & J. W. Stevenson	Yes	18-D-1,2
AH a3-18	Nutrient metabolism and deposition of specific body tissues by pigs with genetic differences in performance, type, and breed	Beltsville, Md.	R. J. Davey, J. W. Stevenson & C. M. Kincaid	Yes	18-A
AH a3-19	To evaluate the nutritive quality and safety of improved cotton-seed meals and reexamine methods for improving the safety in feeding of cotton-seed meals produced under current commercial processes	Beltsville, Md.	J. W. Stevenson, I. P. Earle & C. A. Cabell	Yes	18-B-1,2
AH a4	Pork Studies				
AH a4-3	Meat characteristics of carcasses of pork developed through breeding, nutrition and management	Beltsville, Md.	R. L. Hiner	Yes	21-C-1,2,3

*Initiated during reporting year

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Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl. in	
				Summary of Progress	Area & Subheading
AH b1	Sheep breeding investigations				
AH b1-1	Selective mating and breed comparisons of sheep for farming regions	Beltsville, Md.	G. M. Sidwell, & C. E. Terrill	Yes	13-A-4 13-B-1
AH b1-2	Lamb and wool production from crosses among several breeds of sheep	Beltsville, Md.	G. M. Sidwell, & C. E. Terrill	Yes	13-A-4 13-B-1
AH b1-3	Development of a strain of sheep for maximum production of lambs and wool under farm conditions	Beltsville, Md. Middlebury, Vt.	G. M. Sidwell, & C. E. Terrill	Yes	13-A-4 13-B-1
AH b1-4	Selecting and crossbreeding of Merino sheep for increased productivity	Beltsville, Md.	G. M. Sidwell, & C. E. Terrill	Yes	13-A-4 13-B-1
AH b1-5	Investigations of systems of breeding for improvement of range sheep	Dubois, Idaho, Bozeman, Mont.	S. K. Ercanbrack & R. L. Blackwell	Yes	13-B-3 4-5
AH b1-6	Investigations of traits for use in breeding and selecting of range sheep	Bozeman, Mont.	S. K. Ercanbrack & R. L. Blackwell	Yes	13-A-1 13-B-4
AH b1-7	Studies in physiology of reproduction of range sheep	Dubois, Idaho Logan, Utah	C. A. Hulet & R. L. Blackwell	Yes	14-A-1-2-3- 4-5-6-7
AH b1-8	The occurrence of estrus in sheep as related to reproductive performance	Beltsville, Md.	G. M. Sidwell, & C. E. Terrill	Yes	14-A-9
AH b1-10	Improvement of Navajo sheep by line breeding and selection within the Navajo strain	Ft. Wingate, N.M.	R. D. Humphrey T. D. Hall	Yes	13-A-2-3 15-A-2 15-D-2 21-B-3
AH b1-11	Improvement of fine wool sheep under Southwest conditions	Ft. Wingate, N.M. Univ. Park, N.M.	R. D. Humphrey, T. D. Hall and E. E. Ray	Yes	13-A-2, 3 15-A-2 15-D-2 21-B-3
AH b1-12	Improvement of coarse wool sheep production of wool suitable for Navajo hand weaving	Ft. Wingate, N.M. Univ. Park, N.M.	R. D. Humphrey T. D. Hall and E. E. Ray	Yes	13-A-2, 3 15-A-2 15-D-2 21-B-3
AH b1-13	Influence of breeding on efficiency of gains in range sheep	Dubois, Idaho	K. R. Frederiksen, D. A. Price and R. L. Blackwell	Yes	15-A-2
AH b1-14	Testing of inbred lines of sheep through top crossing	Dubois, Idaho, Beaconsfield, Iowa, Bozeman, Mont., Prosser, Washington	S. K. Ercanbrack & R. L. Blackwell	Yes	13-B-3-5
AH b1-16	Improvement of commercial range sheep through breeding and selection	LaSal, Utah, Logan, Utah, Ft. Collins, Colorado	G. M. Sidwell, T. H. Hall, & M. A. Madsen	Yes	13-B-6
AH b1-17	Development by selective breeding of a strain of sheep which will reproduce more often than once a year and without seasonal restrictions.	Beltsville, Md.	G. M. Sidwell, C. E. Terrill & I. L. Lindahl	Yes	13-B-2
AH b2	Sheep feeding investigations				
AH b2-1 (d2-31)	The cause and prevention of urinary calculi in fattening beef cattle and sheep	College Sta. Tex. Big Springs, Texas	H. R. Crookshank I. L. Lindahl	Yes	15-A-1
AH b2-5	Factors in the utilization of pelleted feeds by sheep	Beltsville, Md. Newark, Dela.	I. L. Lindahl, P. J. Reynolds, C. E. Terrill	Yes	15-A-2
AH b2-6	Investigations of physiological reactions of sheep and other ruminants in relation to metabolic disorders	Beltsville, Md.	I. L. Lindahl	No	
AH b2-7	Investigations on the utilization of forage by sheep	Beltsville, Md. Newark, Dela.	I. L. Lindahl, P. J. Reynolds	Yes	15-A-2-3 15-B-1

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Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj.incl.in	
				Summary of Progress	Area & Subheading
AH b3	Sheep management investigations				
AH b3-1	Investigations of sheep grazing management on ranges of the Intermountain region	Dubois, Idaho	D.A.Price and R.L.Blackwell	Yes	15-C-1
AH b3-4	The response of Targhee sheep to different environments	Dubois, Idaho, Ft.Wingate, N.M., Spooner, Wisc., Beltsville, Md.	C.E.Terrill	Yes	14-B-1
AH b3-5	The effect of shearing, light and season on rate of wool growth	Beltsville, Md.	M.E.Hourihan & C.E.Terrill	No	
AH b3-7	Methods of producing milk fat spring lambs	Ft. Reno, Okla.	J.V.Whiteman, Jr. I.L.Lindahl C.E.Terrill	Yes	13-A-2 13-B-7 15-D-1
AH b3-8	Influence of environment at different geographic locations on fleece and body traits of sheep	Beltsville, Md.	C.E.Terrill	No	
AH b3-9	Investigations of the nutrition and management of range sheep	Dubois, Idaho	D.A.Price and R.L.Blackwell	Yes	15-A-2-3 15-B-2
AH b3-10	Comparative productivity of pastures grazed by beef cattle alone, sheep alone, and the two species in combination	Beltsville, Md.	I.L.Lindahl & P.J.Reynolds	No	
AH b3-11	Influence of management practices on internal parasitism of lambs	Beltsville, Md.	I.L.Lindahl & C.E.Terrill	No	
AH b3-12	Fetal electrocardiography in livestock	Beltsville, Md.	I.L.Lindahl	Yes	14-A-8
AH b4	Goat nutrition investigations				
AH b4-3	Investigation of dairy goat production	Beltsville, Md.	I.L.Lindahl & C.E.Terrill	No	
AH b5	Investigations of wool and other animal fibers				
AH b5-1	Growth and development of the skin, fibers, and accessory follicular structures in goats	Beltsville, Md.	E.H.Dolnick & L.M.Hansen	Yes	14-C-1-2
AH b5-2	Factors affecting quality and value of wool	Dubois, Idaho, Beltsville, Md.	L.O.Wilson, R.L.Blackwell, M.E.Hourihan, C.E.Terrill	Yes	21-E-1
AH b5-3	Evaluation of wool from farm sheep breeding, nutrition, and management studies	Beltsville, Md. Knoxville, Tenn.	M.E.Hourihan, C.E.Terrill	Yes	21-E-2
AH b5-5	Influence of age and season on the skin and follicular structures associated with shedding in Angora goats	Beltsville, Md.	E.H.Dolnick, L.M.Hansen	Yes	14-C-1
AH b5-6	Investigations of wool for the improvement of Navajo, Navajo crossbred, Targhee, and Targhee crossbred sheep under Southwest range conditions	FortWingate, New Mexico	R.D.Humphrey T.H.Hall	Yes	13-A-3
AH b5-7	Relationships of fleece traits to measurable characteristics of card sliver, top, and noils from sheep of known genetic origin	Beltsville, Md. Dubois, Idaho	M.E.Hourihan, C.E.Terrill, L.O.Wilson, R.L.Blackwell	Yes	21-E-3
AH b6	Mutton, lamb and chevon studies				
AH b6-1	Meat characteristics of carcasses of lambs representing certain breeds and crosses	Beltsville, Md.	R.L.Hiner	Yes	21-B-1,2

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				Summary of Progress (Yes-No)	Area & Subheading
AH dl	The improvement of beef cattle through the application of breeding methods.				
AH dl-1 (Rev. #2)	Breed crossing for increased production in beef cattle.	Miles City, Mont.	O. F. Pahnish	Yes	2-A-2 2-B-1 2-C-1
AH dl-2 (Rev. #2)	Development of superior lines of beef cattle.	Miles City, Mont.	O. F. Pahnish	Yes	2-A-3
AH dl-3 (Rev. #2)	The development of more efficient beef cattle for Georgia through the use of selection, progeny testing, inbreeding and crossbreeding.	Tifton and Reidsville, Ga.	B. L. Southwell W. C. McCormick	Yes	2-A-2
AH dl-4 (Rev.)	The improvement of beef cattle for Virginia through breeding methods.	Front Royal, Va.	R. S. Temple B. M. Priode	Yes	2-A-3 3-A-1
AH dl-5 (Rev.)	Selection of cattle adapted to beef production in the Southeastern United States.	Brooksville, Fla.	R. S. Temple W. C. Burns	No	
AH dl-6 (Rev. #2)	Selection for changes in leanness in beef cattle and a study of the response to selection for adaptability in the Gulf Coast area.	Jeanerette, La.	T. M. DeRouen D. C. Meyer-hoeffer	Yes	2-A-2 2-B-2
AH dl-7	Heterosis from crosses among British breeds of beef cattle.	Blacksburg and Steeles Tavern, Va.	J. A. Gaines	No	
AH dl-8 (Rev.)	Evaluation of performance records in beef cattle.**	Fayetteville, Ark.	Warren Gifford	No	
AH dl-9 (Rev. #2)	The improvement of producing ability of beef cattle.	Univ. of Tenn. Agr. Exp. Sta. Knoxville, and seven branch stations.	R. S. Temple C. S. Hobbs	Yes	2-B-1
AH dl-10 (Rev.)	The improvement of beef cattle through breeding methods.	Ames, Iowa	L. N. Hazel E. A. Kline L. E. Johnston J. L. Lush Garold Parks	Yes	2-A-2 2-B-1,2
AH dl-12 (Rev. #2)	Effectiveness of selection for productive efficiency and carcass quality and the importance of heterosis in beef cattle.	Ft. Robinson, and Lincoln, Nebr.	K. E. Gregory	Yes	2-A-1,2 2-B-1,5 2-C-1,2
AH dl-13 (Rev. #2)	The effectiveness of inbreeding and selection in the improvement of performance of beef cattle.	Brookings, S. Dak.	C. A. Dinkel	Yes	2-A-3 2-B-1 2-C-2
AH dl-14 (Rev.)	Breeding and selection of beef for the Southwest.**	Tucson and San Carlos, Ariz.	O. F. Pahnish	No	
AH dl-16 (Rev. #2)	A study of selection, inbreeding and crossing of inbred lines within the Hereford breed.	Ft. Collins, and Ft. Lewis, Colo.	H. H. Stonaker	Yes	2-A-1,3

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				Summary of Progress (Yes-No)	Area & Subheading
AH d1-17 (Rev.)	Recurrent selection and record of performance selection in open and closed beef cattle herds.**	Bozeman and Havre, Mont.	F. S. Willson	No	
AH d1-19 (Rev. #2)	Diallel crossing in beef cattle and its use in breed improvement.	Corvallis, Ore.	Ralph Bogart	Yes	2-A-1,3 2-B-2
AH d1-20 (Rev.)	The development of breeding techniques and selection criteria for improvement of economically important characteristics in Hereford and Shorthorn cattle.**	Logan, Utah	J. A. Bennett	No	
AH d1-22 (Rev.)	The improvement of production and adaptation of beef cattle within pure breeds and certain of their crosses through breeding methods.	College Station, Tex.	T. C. Cartwright	No	
AH d1-23 (Rev.)	Genetic and environmental interactions for performance and carcass traits in beef cattle.	Raleigh, Plymouth, Laurel Springs and Butner, N. C.	E. U. Dillard	Yes	2-B-3 2-C-3
AH d1-27 (Rev. #2)	Relationships of beef and dairy characters in Milking Shorthorn cattle.**	Rosemount and St. Paul, Minn.	C. L. Cole	No	
AH d1-28 (Rev.)	A study to determine the breeding worth of inbred and outbred bulls from various sources.**	State College and Prairie, Miss.	J. C. Taylor	No	
AH d1-29 (Rev.)	Improvement of beef cattle of Alabama through breeding methods.**	Auburn, Ala.	T. B. Patterson	No	
AH d1-30 (Rev.)	Improvement of reproductive performance in beef cattle.**	Jeanerette, La. Beltsville, Md.	W. L. Reynolds	Yes	3-A-2,5
AH d1-31 (Rev.)	Effectiveness of selection for productive efficiency and carcass merit and the development of techniques for the identification of dwarfism carriers in beef cattle.	Ft. Reno and Stillwater, Okla.	D. F. Stephens Doyle Chambers E. J. Turman	No	
AH d1-32 (Rev.)	Genetic-environmental influences on production and carcass traits in beef cattle.	Beltsville, Md.	E. J. Warwick	Yes	2-B-1
AH d1-33 (Rev.)	Increasing reproductive efficiency in range beef cattle.	Miles City, Mont.	R. A. Bellows	Yes	3-A-1,2,3
AH d1-34 (Rev.)	Biochemical and cytological investigations of inherited dwarfism in beef cattle.	Gainesville, Fla.	R. S. Temple Marvin Koger	No	
AH d1-36 (Rev.)	Interactions between genotype and environment in selection for economically important traits in Hereford cattle.	Reno, Nev., and branch stations	C. M. Bailey	Yes	2-B-1
AH d1-37 (Rev.)	Improvement of reproductive performance in beef cattle.	Ft. Robinson, Nebr.	J. N. Wiltbank	Yes	3-A-1,2,3, 4,5

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				Summary of Progress (Yes-No)	Area & Subheading
AH dl-39	Biological and genetic analyses of normal and mutant stocks in beef cattle with special emphasis on dwarfism.**	Davis, Calif.	P. W. Gregory	No	
AH dl-40 (Rev.)	Studies of heterotic effects in crosses of the Angus, Hereford, and Short-horn breeds of cattle.	Davis, Calif.	W. C. Rollins	Yes	2-A-2 2-B-1
AH dl-41	A study of response to selection and genetic-environmental interaction in genetically similar groups of Hereford cattle at two locations.	Miles City, Mont. Brooksville, Fla.	E. J. Warwick	Yes	2-C-3
AH dl-42	Heterosis in beef cattle.	Spickard, Mo.	J. F. Lasley	Yes	2-C-1
AH dl-43	Genetic and environmental influences on traits of economic value in beef cattle.	Madison, Wisc.	E. R. Hauser	No	
AH dl-44	Basic population aspects of qualitative and cytological characters of beef cattle.*	College Station, Tex.	T. C. Cartwright	Yes	2-B-3
AH dl-45	Relationships of beef and dairy characters in Milking Shorthorn cattle.*	Rosemount and St. Paul, Minn.	C. L. Cole R. D. Plowman	Yes	2-C-3
AH dl-46	Breeding and selection of beef cattle for the Southwest.*	Tucson and San Carlos, Ariz.	C. B. Roubicek	Yes	2-A-3 2-B-2

* Initiated during reporting year.

** Discontinued during reporting year.

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				Summary of Progress (Yes-No)	Area & Subheading
AH d2	Beef and Dual Purpose Nutrition Investigations				
AH d2-10 (Rev.)	Cause and prevention of cattle losses on wheat and other pastures with special reference to grass tetany.**	College Station, Tex.	H. R. Crook-shank	No	
AH d2-11 (Rev.)	The effect of interrupted growth on the efficiency of beef production.	Beltsville, Md.	P. A. Putnam	No	
AH d2-12 (Rev.)	Growth, development, and reproductive performance of heifers and cows under different winter treatments.**	Ft. Reno, Okla.	D. F. Stephens	Yes	3-A-1
AH d2-13 (Rev.)	Cause and prevention of acute bloat in ruminants.**	Beltsville, Md.	J. Gutierrez	No	
AH d2-14 (Rev. #2)	Nutritive value of feeds and forages as influenced by lignin, cellulose and other feed components.	Beltsville, Md.	P. A. Putnam	Yes	4-A-1 4-C-2
AH d2-21 (Rev.)	Management and feeding practices affecting the gains of beef cattle on range and in the feedlot.	Ft. Robinson, Nebr.	J. E. Ingalls	No	
AH d2-22 (Rev.)	Determination of the relation between protein and energy deficiencies and reproduction ability of beef cattle.	Beltsville, Md.	J. Bond	Yes	4-B-1 3-A-1
AH d2-24 (Rev.)	The effect of ruminal microorganisms on plant saponins and related compounds.**	Beltsville, Md.	J. Gutierrez	No	
AH d2-26 (Rev.)	Studies on the nutritional relationships between the ruminal protozoa and bacteria and their contribution to digestion in cattle and other ruminants.	Beltsville, Md.	J. Gutierrez	Yes	4-A-5
AH d2-28	The relation of physical form and roughage content to the feeding value of beef cattle rations.**	Beltsville, Md. Front Royal, Va. Ft. Reno, Okla.	P. A. Putnam B. M. Priode D. F. Stephens	No	
AH d2-30	Influence of harvesting factors on the nutritive value of corn and other grains.**	Beltsville, Md.	C. A. Cabell	No	
AH d2-31 & AH b2-1 (Rev.)	The cause and prevention of urinary calculi in fattening beef cattle and sheep.	College Station, Tex.	H. R. Crook-shank	Yes	4-A-3
AH d2-32	Investigations of residues of new pesticides when ingested by beef cattle.	Beltsville, Md. Tifton, Ga.	R. E. Davis B. L. Southwell	Yes	4-A-4
AH d2-34	Evaluation of pastures and forages in the Gulf Coast area in terms of reproductive performance by beef cattle.	Jeanerette, La.	W. L. Reynolds	Yes	3-A-1,3
AH d2-35	The interaction of nutrition and management in the growth and development of beef cattle.	Newell, N. Dak.	J. A. Minyard	Yes	4-A-3 4-C-2 4-F-1

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				Area & Subheading	
AH d2-36	Growth, development, and reproductive performance of heifers and cows under different winter feeding treatments.	Ft. Reno, Okla.	D. F. Stephens	Yes	4-E-1
AH d2-37	The relation of basic ration components and physical state of feeds to their feeding value.	Beltsville, Md. Ft. Reno, Okla.	P. A. Putnam R. R. Oltjen D. F. Stephens	Yes	4-A-1,2 4-C-1
AH d2-38 (C)	Factors affecting the utilization of corn, milo, barley and wheat in rations of beef cattle.	Davis, Calif.	G. D. Lofgreen	Yes	4-C-2
AH d2-39 (C)	A study of relative significance of ruminal and post-ruminal digestion of starch by beef cattle.	Lexington, Ky.	G. E. Mitchell	Yes	4-C-2
AH d2-40 (C)	Formulation of supplements to control feed intake of beef cattle.	Gainesville, Fla.	J. F. Hentges, Jr.	Yes	4-G-1
AH d2-41 (C)	Endocrine function and energy retention of the post-partum beef female as influenced by pre-partum energy intake.	Lincoln, Nebr.	D. R. Zimmerman	No	
AH d2-42	Nutritive evaluation of forages for beef production in the Coastal Plain region.	Tifton, Ga. Beltsville, Md.	B. L. Southwell R. E. Davis	Yes	4-D-1 4-E-1 4-F-1
AH d2-43 (C)	Investigations of pesticide residues ingested by finishing and reproducing beef cattle.*	Front Royal, Va.	K. P. Bovard	Yes	4-A-4

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** Discontinued during reporting year.

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				Summary of Progress (Yes-No)	Area & Subheading
AH d3	Beef and Dual Purpose Management Investigations				
AH d3-1 (Rev. #2)	Sustained beef cattle production and maintenance of range quality in the Northern Great Plains by use of supplemental spring pastures.	Miles City, Mont.	J. J. Urick	Yes	4-E-1
AH d3-2 (Rev.)	Management of pastures and cattle for beef production.	Brooksville, Fla.	W. C. Burns	Yes	4-E-1 3-A-1
AH d3-3 (Rev. #2)	Improving herd management on forest range.	Alapaha, Ga.	B. L. Southwell	No	
AH d3-4 (Rev. #2)	Integration of livestock and timber production on intensively managed pastures.	Alapaha, Ga.	B. L. Southwell	No	
AH d3-6	The comparisons of the production of beef from beef, dual-purpose and dairy steers.	Beltsville, Md.	J. Bond E. J. Warwick R. E. Davis J. W. Thomas N. W. Hooven R. L. Hiner	Yes	5-A-6
AH d3-7	Effects of management and growth variables on performance and carcass merit in beef cattle.	Ft. Reno, Okla.	D. F. Stephens	No	

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				Summary of Progress (Yes-No)	Area & Subheading
AH d4	Beef and Veal Studies				
AH d4-4 (Rev.)	Histological characteristics of muscle tissue of beef developed through breeding, nutrition and management.	Beltsville, Md.	R. L. Hiner	Yes	21-A-1, 3(c)
AH d4-5 (Rev.)	Characterization of attributes affecting tenderness in beef as related to production factors.	Beltsville, Md. College Station, Tex.	R. L. Hiner R. L. Hostetler	Yes	21-A-1
AH d4-6 (Rev.)	Biochemical and physical characteristics of beef as affected by production factors.	Beltsville, Md.	R. L. Hiner	Yes	21-A-3 (a), (b)
AH d4-7	Meat characteristics of carcasses of beef developed through breeding, nutrition and management.	Beltsville, Md.	R. L. Hiner	21-A-2	

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				Summary of Progress	Area & Subheading
AH e1	Poultry breeding investigations				
AH e1-43 (C) (Rev.)	Evaluation of breeding systems for chickens.	Lafayette, Ind. & 11 North Central State Experiment Stations	S. P. Wilson & Cooperators	Yes	8-B-1,2
AH e1-44 (Rev.)	Development and evaluation of breeding techniques in chickens,	Athens, Ga., & 14 Southern State Experiment Stations	L. D. Tindell & Cooperators	Yes	8-A-4 8-B-2
AH e1-46	Genetic and environmental factors affecting reproduction in turkeys.**	Six Western State Experiment Stns.	R. E. Cook & Cooperators	No	
AH e1-47	Avian reproduction under subcircadian periodicities.	Beltsville, Md.	H. L. Marks	Yes	8-A-3
AH e1-48	Genetic aspects of the ability of chickens to utilize amino acids.	Beltsville, Md.	R. E. Cook	Yes	8-A-1
AH e1-49	Genetic aspects of feed utilization in the chicken.	Beltsville, Md.	R. E. Cook	No	
AH e1-50	Breeding chickens for resistance to gonadotropic hormone inhibition.	Beltsville, Md.	R. E. Cook	No	
AH e1-51	Performance of fowl as influenced by physiological traits and pleiotropic genes.	Twelve North-eastern State Experiment Stations	R. E. Cook & Cooperators	Yes	
AH e1-52	Biochemical basis for genetic differences in growth rate.	Beltsville, Md.	P. D. Lepore	Yes	8-A-2
AH e1-53	Selection for hatchability of turkey eggs at different altitudes.*	Three Western State Experiment Stations	R. E. Cook & Cooperators	No	
AH e2	Poultry nutrition investigations				
AH e2-13	Fat metabolism in poultry.**	Beltsville, Md.	H. Menge & C. C. Calvert	Yes	10-B-1
AH e2-14	Feeding systems in poultry.**	Beltsville, Md.	R. J. Lillie	Yes	10-C-2
AH e2-15	Effect of high air temperatures on optimum levels of nutrients in diets of chickens.	Glendale, Arizona	B. W. Heywang	Yes	10-C-2
AH e2-16	Protein-amino acid requirements of chickens and turkeys.	Beltsville, Md.	R. J. Lillie	Yes	10-C-3
AH e2-17	Cottonseed meal in chicken diets.	Glendale, Arizona	B. W. Heywang	Yes	10-C-1
AH e2-18	Mineral requirements of poultry.	Beltsville, Md.	C. A. Denton & R. J. Lillie	No	
AH e2-19 (C)	Malathion residues in poultry meat and eggs.*	Ames, Iowa	C. A. Denton	No	
AH e2-20	Energy and fatty acids in poultry nutrition.*	Beltsville, Md.	H. Menge & C. C. Calvert	Yes	10-A
AH e3	Poultry physiology investigations				
AH e3-18	Effects of environmental variables on reproduction in turkeys.	Beltsville, Md.	S. J. Marsden & R. M. Fraps	Yes	9-B-1
AH e3-19	Parthenogenesis in avian eggs.	Beltsville, Md.	M. W. Olsen, H. K. Poole & R. M. Fraps	Yes	9-A-3

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				Summary of Progress	Area & Subheading
AH e3-20	The homograft reaction and immunological tolerance in birds.	Beltsville, Md.	H. K. Poole, M. W. Olsen and R. M. Fraps	Yes	9-A-4
AH e3-21	Mechanisms controlling oviposition and ovulation in birds.	Beltsville, Md.	H. Opel and R. M. Fraps	Yes	9-A-1
AH e3-22	Pituitary-ovarian relationships controlling egg production in the Coturnix quail.	Beltsville, Md.	H. Opel and R. M. Fraps	Yes	9-A-2
AH e3-23	The effects of controlled photo-periods and light intensity on growth and egg production of chickens.*	Glendale, Arizona	R. W. Lowe and B. W. Heywang	Yes	9-B-2 9-B-3
AH e3-24	The effect of various densities on egg production and mortality in caged and floor housed pullets.*	Glendale, Arizona	R. W. Lowe and B. W. Heywang	No	
AH e3-25	Control of eggshell pigmentation in Japanese quail.*	Beltsville, Md.	H. K. Poole and R. M. Fraps	Yes	9-A-5
AH e4	Poultry meat and egg quality as affected by nutrition, breeding, physiology and other management factors				
AH e4-9 (Rev.)	Effect of age, sex, breed and management on the physical, chemical, and morphological characteristics of poultry skin.**	Beltsville, Md.	E. H. McNally	No	
AH e4-10	Effect of breeding and management of flock on the chemical and morphological characteristics of the yolk and yolk membrane of chicken eggs.**	Beltsville, Md.	E. H. McNally	Yes	21-D
AH e4-11	The effect of hen's age, season, environmental temperature and on-farm holding conditions on egg quality.	Glendale, Arizona	R. W. Lowe and B. W. Heywang	No	
AH e5	National Poultry and Turkey Improvement Plans (There are no line projects under this Work Project).	Beltsville, Md., in cooperation with 47 Official State Agencies (Alaska, Hawaii and Nevada not included)	S. A. Moore and R. D. Schar	Yes	20-B-1,2
AH e6	Improvement of viability of poultry				
AH e6-2 (Rev. #2)	The development and maintenance of inbred lines of chickens showing a wide range of resistance and susceptibility to avian lymphomatosis.	East Lansing, Mich.	L. B. Crittenden	No	
AH e6-3 (Rev. #2)	The production and maintenance of susceptible chickens free of lymphomatosis.	East Lansing, Mich.	L. B. Crittenden, J. J. Solomon and B. R. Burmester	No	
AH e6-10 (Rev. #2)	A study of the characteristics of the causative agent of visceral lymphomatosis in the chicken.**	East Lansing, Mich.	B. R. Burmester	Yes	11-A

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				Summary of Progress	Area & Subheading
AH e6-17 (Rev. #2)	Studies on the immunity of chickens to visceral lymphomatosis.	East Lansing, Mich.	W. Okazaki	Yes	11-B
AH e6-20 (Rev.)	Identification of cell types found in the lesions and blood of chickens with the the different forms of the avian leukosis complex.**	East Lansing, Mich.	A. M. Lucas and E. M. Denington	No	
AH e6-21 (C) (Rev.)	Effect of feeding cod liver oil on the occurrence of lymphomatosis in chickens**	East Lansing, Mich.	B. R. Burmester and B. Winton	No	
AH e6-24 (Rev.)	Studies of the chicken tumor viruses <u>in vitro</u> .	East Lansing, Mich.	J. J. Solomon and B. R. Burmester	Yes	11-A
AH e6-27	Studies on the epizootiology of avian lymphomatosis and related neoplasms.	Michigan, Ind. and New Jersey	B. R. Burmester	Yes	11-C
AH e6-28	A study of the genetic variability remaining in highly inbred lines of chickens.	East Lansing, Mich.	L. B. Crittenden and W. Okazaki	No	
AH e6-29 (C) (Rev.)	A study of genetic resistance and susceptibility to virus induced neoplasms of chickens.*	East Lansing, Mich. and N. Y.	L. B. Crittenden, W. Okazaki and H. G. Purchase	Yes	11-E
AH e6-30 (C)	Studies on the etiology of the acute lymphomatosis syndrome.*	East Lansing, Mich., Ga. and Connecticut	R. L. Witter and B. R. Burmester	Yes	11-A
AH e6-31	Studies of host-cell oncogenic virus relationship.*	East Lansing, Mich.	R. W. Hinz and B. R. Burmester	Yes	11-D
AH e7	Relation of management and genetics to broiler losses				
AH e7-1	Factors influencing airsacculitis and condemnations in broilers.	State College, Miss.	R. T. Parkhurst	Yes	12-B
AH e7-2	Genetic aspects of resistance and susceptibility of chickens to Newcastle disease virus.*	Athens, Ga.	C. D. Gordon	Yes	12-A
AH e7-3	Response of chickens to hormonal and environmental stimuli.*	Athens, Ga.	H. S. Siegel	Yes	12-C
AH e7-4	Management factors influencing airsacculitis and condemnation in broilers.*	State College, Miss.	R. T. Parkhurst and J. W. Deaton	Yes	12-B
AH e8	Avian anatomy investigations				
AH e8-1	Skeletal and muscular systems of domesticated and laboratory birds.	East Lansing, Mich.	A. M. Lucas	Yes	1-B

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				Summary of Progress	Area & Subheading
AH f1	Fur animal breeding(including rabbits)				
AH f1-1	Genetic investigations of traits for use in breeding and selection for improvement of meat rabbits	Fontana, Calif. Davis, Calif.	R. B. Casady	Yes	19-A-1-2-3
AH f1-2	Genetics of mink and marten with emphasis on mutant characters and pelt quality	Madison, Wisc.	R.M.Shackelford	No	
AH f1-3	Development of a superior strain of silver foxes	Petersburg, Alaska	J. R. Leekley	Yes	19-B-2
AH f1-4	Marten mating systems to increase breeding regularity and prolificacy	Petersburg, Alaska	J. R. Leekley	Yes	19-B-3
AH f1-6	Effect of breeding does at various intervals following kindling on the growth and weaning weight of the young and on reproductive performance of the doe	Fontana, Calif.	R. B. Casady	Yes	19-B-1
AH f1-7	Investigations of spontaneous glaucoma in rabbits	Fontana, Calif.	R. B. Casady	No	
AH f2	Fur animal physiology of reproduction				
AH f2-1	Effect of hormones on growth and reproduction of mink	Ithaca, N.Y., Madison, Wisc., Swarthmore,Pa.	H.F. Travis, R.M. Shackelford R.K. Enders	Yes	19-B-5-6-7
AH f2-5	Investigation of fetal development and fetal anomalies in rabbits	Fontana, Calif.	R.B. Casady	No	
AH f3	Fur animal feeding and nutrition				
AH f3-1	Development of diets based on ocean and fresh water fish and sea mammals and their products for blue fox, mink and marten	Petersburg, Alaska	J. R. Leekley and C.A.Cabell	Yes	19-C-1-2
AH f3-2	Relationship of nutrient factors and physical characteristics in diet to rabbit production	Fontana, Calif.	R. B. Casady	Yes	19-C-4-5-7
AH f3-4	Study of various proteins as rabbit feed	Fontana, Calif.	R. B. Casady	Yes	19-C-6
AH f3-5	Investigation of the basic nutrient requirements and nutrient utilization by mink	Ithaca, N.Y.	H. F. Travis	Yes	19-C-3
AH f3-6	The development of practical diets and feeding practices for mink	Ithaca, N. Y.	H. F. Travis	No	
AH f3-7	Investigations of hydrocephalus in vitamin A deficient rabbits **				
AH f4	Fur fiber and fur investigations				
AH f4-3	The priming process in fur bearing animals	Beltsville, Md.	E. H. Dolnick	Yes	19-B-4
AH f4-4	Influence of endocrine factors on the development of fur-bearing animals	Beltsville, Md.	E. H. Dolnick	No	

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				Summary of Progress	Area & Subheading
AH g1	Genetics and interrelations of anatomical and physiological characteristics of dairy cattle.				
AH g1-1	Genetic and phenotypic relation of body form in the growing heifer to body form and producing capacity in the cow.**	Beltsville, Md. Urbana, Ill. Columbus, Ohio Lafayette, Ind. St. Paul, Minn.	R. D. Plowman C. A. Matthews	No	
AH g1-2	Genetic and phenotypic interrelationships between body form, internal anatomy and milk production in the cow.**	Beltsville, Md.	R. D. Plowman C. A. Matthews	Yes	5-A-1,2,3
AH g1-3	Studies on the rate and form of mammary gland development in cattle at different ages, in relation to milk production.**	Beltsville, Md. St. Paul, Minn. Huntley, Mont. Columbus, Ohio Lewisburg, Tenn. Madison, Wisc.	R. D. Plowman C. A. Matthews	No	
AH g1-4	Studies of the genetics of feed utilization in dairy cattle.	Beltsville, Md. Ithaca, N.Y. Lewisburg, Tenn. Jackson, Tenn. Huntley, Mont. Bozeman, Mont. Logan, Utah	N. W. Hooven, Jr. G. W. Trimmerger J. Owen B. Hazelwood D. Kopland J. Boyd R. Lamb	Yes	5-A-4,5
AH g1-5	Studies of the genetics of milk constituents and other properties related to milk production.	Beltsville, Md. E. Lansing, Mich. Madison, Wisc.	C. A. Kiddy	Yes	5-A-7
AH g1-6	A study involving the repeatability and standardization of blood typing in dairy cattle.	Beltsville, Md. & cooperating laboratories	C. A. Kiddy R. D. Plowman	Yes	5-A-8
AH g1-7	The importance of immunogenetic factors in problems of lowered fertility in cattle.	Beltsville, Md.	C. A. Kiddy H. W. Hawk	No	
AH g1-8	Antibodies in bovine milk.	Beltsville, Md.	C. A. Kiddy R. D. Plowman W. D. Schultze	No	
AH g1-9 (C)	Development and evaluation of various methods of raising meat animals from dairy and beef calves.	Madison, Wisc.	W. J. Tyler R. D. Plowman	No	
AH g1-28 (dl-45)	Relationships of beef and dairy characteristics in milking Shorthorn cattle.	St. Paul, Minn. Waseca, Minn.	C. L. Cole W. F. Aunan R. D. Plowman E. J. Warwick	No	
AH g2	The application of advanced genetic concepts and principles for the improvement of dairy cattle.				
AH g2-5	Developing and evaluating desirable production characteristics in Holstein cattle by inbreeding, outbreeding and inter-line crossing.	Lake Mills, Wisc. Madison, Wisc.	W. J. Tyler R. D. Plowman	Yes	5-B-1
AH g2-22	Studies to estimate the relative importance of general and specific combining ability in relation to breeding dairy cattle.	St. Paul, Minn. Columbus, Ohio	R. D. Plowman C. W. Young T. M. Ludwick	No	
AH g2-23 (Rev.)	Evaluation of interbreed matings as a genetic method for improving economically important traits in dairy cattle.	Beltsville, Md. Urbana, Ill. Lafayette, Ind.	R. E. McDowell R. W. Touchberry T. G. Martin	Yes Yes No	5-B-4a,b,c, d,e,f

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				Summary of Progress	Area & Subheading
AH g2-24	The influence of parental relationship on the genetic merit of dairy sires and cows.	Beltsville, Md.	R. D. Plowman	Yes	5-B-2
AH g2-25	The value of the continuous use of progeny tested sires and sons of progeny tested for improving dairy cattle.	Beltsville, Md.	R. D. Plowman	Yes	5-B-3
AH g2-26	Comparisons of genetic methods of using sires available in artificial breeding of dairy cattle.	St. Paul, Minn.	C. W. Young	No	
AH g2-27	Comparison of selection for milk production with selection for total fat production in dairy cattle.**	Cortland, N.Y.	G. W. Trimberger C. R. Henderson	No	
AH g2-28	A comparison of selection for milk production with selection for high protein percent in dairy cattle.*	Cortland, N.Y.	C. R. Henderson	No	
AH g3	Investigations of dairy herd management.				
AH g3-8	Evaluation of management practices for the control of bovine mastitis.	Beltsville, Md.	W. D. Schultze	Yes	6-B-1,3 7-D-1
AH g3-10	Electrically controlled and operated equipment for reduction of labor in dairy production.	Beltsville, Md.	R. D. Plowman	Yes	7-D-2
AH g3-12	Evaluation and development of equipment and physical methods for control of flies and other dairy cattle pests.	Beltsville, Md.	R. D. Plowman	Yes	7-D-3a,b,c, d,e
AH g3-13 (C)	Evaluation of mechanical sanitation as a means of reducing fly populations on dairy farmsteads.*	Baton Rouge, La.	J. B. Frye R. D. Plowman	No	
AH g4	Factors influencing dairy cattle adaptability.				
AH g4-1	Relationship of anatomical and physiological characteristics to dairy cattle adaptability.	Baton Rouge, La. Tifton, Ga. College Sta., Tex. Beltsville, Md.	J. E. Johnston J. C. Johnson M. A. Brown R. E. McDowell	Yes	6-C-1,2,3, 4,5
AH g4-2	Genetic methods for developing adaptability.	College Sta., Tex. Beltsville, Md. Baton Rouge, La. Jeanerette, La. Reidsville, Ga. Tifton, Ga.	M. A. Brown C. Branton B. Hollon J. C. Johnson J. C. Johnson	Yes	5-A-8 5-B-5
AH g4-3	Influence of management practices and other environmental factors on adaptability of dairy cattle to hot and humid regions.	Tifton, Ga. Baton Rouge, La. Jeanerette, La.	J. C. Johnson B. Hollon	Yes	7-D-6
AH g5	Evaluation of concepts for procurement, interpretation and use of dairy herd records.				
AH g5-1	Studies on methods for minimizing environmental influences on production records of individual cows and progeny records.	Madison, Wisc. Beltsville, Md. College Pk., Md.	E. L. Corley	Yes	7-D-4,5
AH h1	The nutritional factors affecting normal growth and health of calves and growing cattle.				
AH h1-1	Wilted alfalfa silage as a forage for growing dairy heifers.	Beltsville, Md.	D. R. Waldo M. Okamoto R. W. Miller	Yes	7-C-1,2

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				Summary of Progress	Area & Subheading
AH h1-5	The utilization of the carotene from corn silage by dairy calves.*	Beltsville, Md.	R. W. Miller D. R. Waldo T. R. Wrenn W. C. Jacobson L. A. Moore	Yes	7-C-3
AH h2	A study of nutritional and related factors affecting the usefulness of producing dairy cattle.				
AH h2-3	Studies on the microbiology of bovine rumen.	Beltsville, Md.	K. A. Pittman	Yes	1-F-1,2,3
AH h2-5	Factors involved in the efficiency of forage utilization by dairy heifers.	Beltsville, Md.	D. R. Waldo G. F. Fries	No	
AH h2-6	Development and use of chemical methods for determining the nutritive values of dairy feeds and forages.	Beltsville, Md.	P. J. VanSoest	Yes	7-A-3a,b,c,d
AH h2-7	The measurement of heat production of grazing cattle.	Beltsville, Md.	D. R. Waldo W. P. Flatt	No	
AH h2-8	Determination of the nutritive value of cattle feeds by calorimetric methods.	Beltsville, Md.	W. P. Flatt P. W. Moe	Yes	7-A-1,2
AH h2-10 (C)	Study of the metabolism and excretion of ingested radionuclides in relation to nutrition and health of farm animals and to the accumulation of radionuclides in animal food products.	Ithaca, N.Y. Beltsville, Md.	C. L. Comar G. F. Fries	Yes	1-G-1,2
AH h2-11	A study of the efficiency of use of metabolizable energy for growth of dairy cattle.	Beltsville, Md.	E. A. Kane	No	
AH h2-12 (C)	Effects of liberal concentrate feeding on health, reproductive efficiency, milk production, economy of milk production and other related responses.	Ithaca, N.Y.	J. K. Loosli L. A. Moore	No	
AH h2-13 (C)	Factors affecting the absorption and excretion of Heptachlor Epoxide by dairy animals.	College Pk., Md.	R. F. Davis R. L. King R. W. Hempken C. H. Gordon J. C. Derbyshire L. A. Moore	No	
AH h2-14	Pesticide residues in the tissues and milk of dairy cattle.*	Beltsville, Md. Tifton, Ga.	L. A. Moore C. H. Gordon E. A. Kane J. C. Derbyshire	Yes	7-A-4a,b,c
AH h3	Studies on the management, preservation and utilization of grassland crops for dairy cattle.				
AH h3-1	A biochemical study of the ensiling of forage crops.	Beltsville, Md.	W. C. Jacobson	Yes	7-B-8
AH h3-3	A study of the effects of kinds of crop, kinds of treatment, methods of handling and conditions of storage of forage on the resulting silages and the production of silages suitable for fundamental bacteriological and biochemical studies.	Beltsville, Md.	C. H. Gordon	Yes	7-B-1,2,3,4,5,6,7
AH h3-12	Investigation of factors affecting forage production of Tennessee grasslands for dairy cattle.	Lewisburg, Tenn.	D. R. Waldo	No	

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				Summary of Progress	Area & sub-heading
AH h3-17	The relation of date of cutting and dry matter content when cut to digestibility, consumption and acre nutrient yields of forage crops.	Huntley, Mont.	D. R. Waldo G. F. Fries	No	
AH h3-18	The effect of varying stocking rates on nutrient yields per acre of orchard-grass-ladino clover pastures and on production per animal.	Beltsville, Md.	C. H. Gordon J. C. Derbyshire	No	
AH h3-19	Concentrate supplementation responses of dairy cows on pasture and dry lot conditions.	Logan, Utah Beltsville, Md.	M. J. Anderson D. R. Waldo	No	
AH h3-20 (C)	The effects of variety, selection and production methods of corn on the cost and feeding value of corn silage for dairy cattle.	College Pk., Md.	C. H. Gordon	No	
AH h4	Bioassay of nutritional requirements and processes of dairy cattle.				
AH h4-1	Unidentified nutrients in milk, milk products and related foods and feeds.**	Beltsville, Md.	A. M. Hartman L. P. Dryden	Yes	1-E-5
AH h4-3	The metabolic function of vitamin B ₁₂ .	Beltsville, Md.	A. M. Hartman L. P. Dryden	Yes	1-E-1,2,3,4
AH h4-4	Production of vitamin B ₁₂ by micro-organisms of the bovine rumen.**	Beltsville, Md.	A. M. Hartman L. P. Dryden	No	
AH h5	Physiological studies of reproduction, mammary gland growth and lactation in dairy cattle.				
AH h5-1	Hormonal and nutritional aspects of mammary growth and lactation.	Beltsville, Md.	J. Bitman T. R. Wrenn	Yes	1-D-2
AH h5-2	Development of methods for the determination of secretion rate and metabolism of hormones in dairy cattle.	Beltsville, Md.	J. Bitman	No	
AH h5-3	Physiological mechanisms related to reproductive performance of dairy cattle.**	Ithaca, N.Y.	J. Bitman H. W. Hawk W. Hansel	No	
AH h5-4	Pre- and post-ovulatory factors affecting fertilization and embryonic survival in dairy cattle.**	Amherst, Mass.	H. W. Hawk D. L. Black	No	
AH h5-6	Physiological basis for variations in fertilization success and embryo survival that may be associated with lowered fertility in cattle.	Madison, Wisc. Beltsville, Md.	L. E. Casida H. W. Hawk	Yes	1-D-3a 6-A-1,2
AH h5-8	Endocrine influences on embryonic mortality and uterine physiology.	Beltsville, Md.	H. W. Hawk	Yes	1-D-1a,b,c 1-D-3a,b 1-D-4a,b,c
AH h5-9	Physiological defensive mechanisms of the mammary gland as related to mastitis.*	Beltsville, Md.	H. W. Hawk J. Bitman W. D. Schultze R. D. Plowman	No	
AH i4	Dairy herd improvement research through analyses of data collected in National Cooperative Dairy Herd Improvement and Sire-Proving Programs and the development of effective production testing organizations.	Beltsville, Md. New Orleans, La. Arlington, Va.	E. L. Corley	No	

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				Summary of Progress	Area & sub- heading
AH i4-1	Research on the evaluation of superior sires and cows in the national dairy herd and on the factors affecting these estimations.	Beltsville, Md. New Orleans, La. Arlington, Va. Bethesda, Md.	E. L. Corley R. H. Miller B. T. McDaniel	Yes	20-A-1,2
AH i4-2	Analysis of different types of records of performance and breeding society organizations, testing plans, methods and production records to improve the effectiveness of DHIA sire-proving and related programs.	Beltsville, Md. New Orleans, La. Arlington, Va. Bethesda, Md.	E. L. Corley R. H. Miller B. T. McDaniel	Yes	20-A-3
AH i4-3	Analysis of DHIA cow and herd production records to determine from year to year the relationships between yield, feed inputs, costs and related factors.	Beltsville, Md. New Orleans, La. Arlington, Va.	E. L. Corley J. King R. H. Miller B. T. McDaniel	Yes	20-A-4a,b, c,d,e
AH j1	Humane slaughter of meat animals.			No	
AH k1	Basic metabolism, fate and role of agricultural chemicals ingested by livestock.*	Fargo, N.D.	E. J. Thacker	Yes	1-A-1,2,3
AH p1	Pioneering Blood Antigen Laboratory.	Beltsville, Md.	S. L. Schein- berg	Yes	1-C-2a,b
AH p2	Methods and theories of population genetics.	Lafayette, Ind.	W. H. Kyle	Yes	1-C-1

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				Summary of Progress	Area & Sub-heading
A7-AH-1	PL 480 Projects Physiology and genetics of characteristics influencing the adaptability of cattle and buffalo for dairy production in India; genetic methods for developing adaptability and the effect of climatic elements and other environmental influences on adaptability.	Izatnagar, India	G. Guha (R.E. McDowell)	Yes	6-C-7
A7-AH-6	Nutritional physiology of different breeds of Indian cattle.	Karnal, India	D. N. Mullick (R.E. McDowell)	Yes	6-C-8
A7-AH-11	Factors affecting the utilization of low-grade roughages and production of volatile fatty acids in the rumen of cattle.	Punjab, India	G. S. Sidhu (L. A. Moore)	No	
A7-AH-18	Investigations on milk and meat potentialities of Indian goats.	Uttar Pradesh, India	S. N. Singh (I. L. Lindahl)	No	
A7-AH-21	Evaluation of feedstuffs available in India for protein quality and energy values.	Ludhiana, India	G. Sidhu (C. A. Denton)	No	
A7-AH-23	Collection and evaluation of native fowl germ plasm. *	India	Dalbir Singh (R. E. Cook)	No	
A10-AH-2	Comparative studies of 'repeat breeders' and normal cows and heifers.	Beit Dagan, Israel	Nathan Ayalon (J. Bitman)	No	
A10-AH-3	The mechanism of lactation and its augmentation by hypothalamic stimulation.	Jerusalem, Israel	F. G. Sulman (J. Bitman)	Yes	6-B-2
A10-AH-7	Utilization and function of vitamin A in nutrition of poultry.	Jerusalem, Israel	A. Bondi (C. A. Denton)	Yes	10-B-3
A10-AH-8	Utilization of different kinds of protein feeds by ruminants. *	Rehovot, Israel	A. Bondi (P.J. Reynolds)	Yes	15-A-2
A10-AH-9	The effect of X-rays on viability genes with special reference to their action in heterozygotes and to the mechanism of heterosis.	Jerusalem, Israel	Raphael Falk (S.L.Scheinberg)	No	
A10-AH-12	The separation of young and old spermatozoa.	Rehovot, Israel	R. Volcani (R. J. Gerrits)	No	
A10-AH-13	Factors acting in long-term storage of sperm <u>in vivo</u> .	Rehovot, Israel	R. Volcani H. Schindler (R. J. Gerrits)	No	
A10-AH-14	Bacteriological problems in artificial insemination of hens. *	Israel	M. Perek (R. E. Cook)	No	
A10-AH-16	Some aspects of the carbohydrate and fat economy of lactating sheep with particular reference to Ketosis. *	Jerusalem, Israel	E. Wertheimer and J. Adler (I. L. Lindahl)	No	

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				Summary of Progress	Area & Sub-heading
A10-AH-17	Water transport through animal membranes: Influence of the pH and the ionic composition of the bathing fluids on the effect of vasopressin. *	Jerusalem, Israel	T. D. Ullman (J. Bitman)	No	
A10-AH-20	Studies on calcium and phosphorus metabolism in the chicken; investigation of the factors influencing egg shell quality. *	Rehovot, Israel	Samuel Hurwitz (C. A. Denton)	Yes	10-B-2
A22-AH-2	White muscle disease of lambs in Turkey.	Ankara, Turkey	Cahit Ozcan (I. L. Lindahl)	Yes	15-A-1
E8-AH-1	Breed differences regarding the antigenic properties of cattle blood, their inheritance in relation to economic characteristics and genetic origin of the breed.	Tikkurila, Finland	Viljo Vainikainen (C. A. Kiddy)	Yes	5-A-9
E21-AH-1	Secretion of anterior pituitary hormones & ovulation in small ruminants.	Jablonna, Poland	E. Domanski (J. Bitman)	No	
E21-AH-2	Color in pork as influenced by heredity, sex, age, feeding & management of animals.	Warsaw, Poland	M. A. Janicki (R. L. Hiner)	Yes	21-C-3
E21-AH-4	Investigations of blood groups in a new racial group of the "Zlotnicka Pig."	Poznan, Poland	Antonio Kaczmarek (C. M. Kincaid)	No	
E21-AH-5	Protein compounds of vitamin B ₁₂ and its analogs.	Poznan, Poland	J. Janicki (A. M. Hartman)	No	
E21-AH-6	Trace element contents in forage crops in relation to the stage of development of the plants, method of gathering and storage.	Poznan, Poland	K. Gawecki (R. E. Davis)	Yes	4-F-1
E21-AH-7	The reactions in the guinea pig liver microsomes during the protein biosynthesis <u>in vitro</u> .	Warsaw, Poland	J. Heller P. Szafranski (R. Oltjen)	Yes	4-B-1
E21-AH-8	The influence of somatotrophin (STH - growth hormones) on fat metabolism in adult hens. *	Warsaw, Poland	W. Herman (R. M. Fraps)	No	
E25-AH-4	Contribution to the study of metabolism of zinc in living organisms by means of zinc 65.	Madrid, Spain	Carmen Garcia (C. A. Cabell)	No	
E25-AH-6	A pilot study with Tribolium of the influence of environmental stress on genetic parameters and response to selection.	Madrid, Spain	F. Orozco (R. E. Cook)	No	
F4-AH-1	Improving and evaluating Fayoumi and Dandarawi fowls.	Dekki, Giza, Egypt	I. F. Sayed (R. E. Cook)	No	

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				Summary of Progress	Area & Sub- heading
S3-AH-7	Structural and physiological characteristics associated with adaptability of cattle in tropical and sub-tropical areas.	Pirassununga, Brazil	J. S. Veiga (R.E. McDowell)	Yes	6-C-6
S5-AH-1	Evaluation of the native breed, Costeno con Cuernos, and European breeds and European-native breed crosses when managed and selected for dairy cattle traits under the hot and humid conditions of Northern Colombia.	Turipana, Colombia	R. K. Waugh (R.E. McDowell)	Yes	5-B-5
S9-AH-1	The nutritional value of the fish silage produced by yeasts fermentation for animal feeding.	Montevideo, Uruguay	Victor H. Bertullo (C. A. Cabell)	No	

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